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ALASKA GROUNDFISH FISHERIES

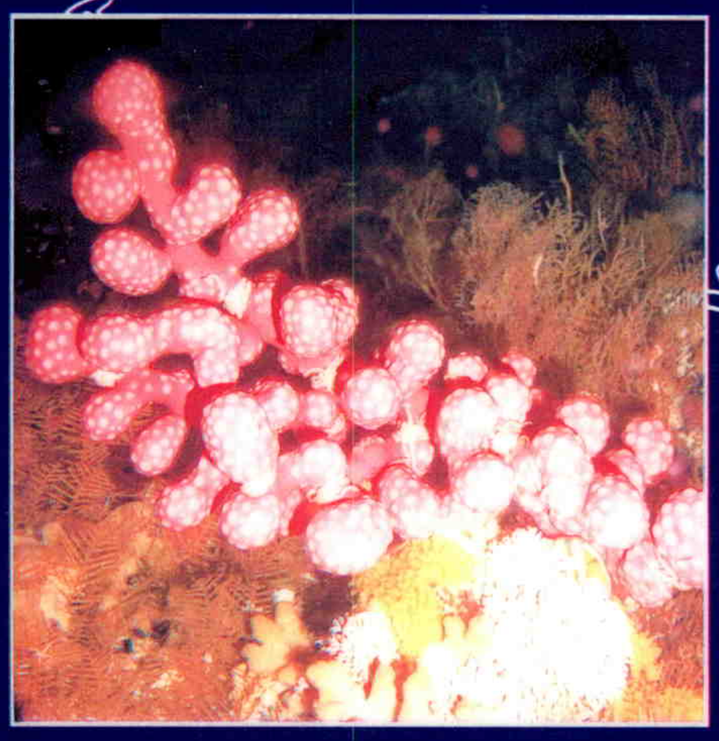
FINAL PROGRAMMATIC SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

VOLUME II: CHAPTER 4 (SECTIONS 4.0 TO 4.6)









United States Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service Alaska Region

June 2004

Alaska Groundfish Fisheries

Final Programmatic Supplemental Environmental Impact Statement

Executive Summary

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Chapter 2 – The Programmatic Alternatives
Chapter 3 – Affected Environment

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Alaska Groundfish Fisheries
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ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ABC	Acceptable Biological Catch
ACC	Alaska Coastal Current
AD	Automatic Differentiation
ADCED	Alaska Department of Community and Economic Development
ADEC	Alaska Department of Environmental Conservation
ADF&G	Alaska Department of Fish and Game
AEB	Aleutians East Borough
AFA	American Fisheries Act
AFSC	Alaska Fisheries Science Center
AKAPAI	Alaska Peninsula and Aleutian Islands
AKKO	Alaska Kodiak Region
AKR	Alaska Region
AKSC	Southcentral Alaska
AKSE	Southeast Alaska
ANCSA	Alaska Native Claims Settlement Act
ANHSC	Alaska Native Harbor Seal Commission
AP	Advisory Panel
APA	Administrative Procedure Act
APAI-SP	Alaska Peninsula and Aleutian Islands Shore Plant
APEC	Asia Pacific Economic Cooperation
APICDA	Aleutian Pribilof Island Community Development Association
A-R-S-O	Atka Mackerel-Rockfish-Sablefish and Other Groundfish Species
AYK	Arctic-Yukon-Kuskokwim
B	Biomass Proxy Value
BBEDC	Bristol Bay Economic Development Corporation
BiOp	Biological Opinion
BRD	Biological Research Division
BSAI	Bering Sea and Aleutian Islands
BSP	Bering Sea Pollock
BSP-SP	Bering Sea Pollock Shore Plant
BTLC	Bird Treatment and Learning Center
CS-	Conditionally Significant Adverse
CS+	Conditionally Significant Beneficial
CAFF	Conservation of Arctic Flora and Fauna
CAR	Comment Analysis Report
CBSFA	Central Bering Sea Fishermen's Association
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CDQ	Community Development Quota
CEQ	Council on Environmental Quality
CFEC	Commercial Fisheries Entry Commission
CFIVSA	Commercial Fishing Industry Vessel Safety Act
CFR	Code of Federal Regulations
CFZ	Contiguous Fishing Zone

ACRONYMS AND ABBREVIATIONS (Cont.)

CG	Central Gulf of Alaska
CH	Critical Habitat
CIMMC	Cook Inlet Marine Mammal Commission
cm	Centimeter
cm/sec	Centimeters per Second
CMSA	Consolidated Metropolitan Statistical Area
COAR	Commercial Operations Annual Report
CP	Catcher Processor
CPUE	Catch-Per-Unit-Effort
CV	Catcher Vessel
CVM	Contingent Valuation Method
CVRF	Coastal Villages Region Fund
CWT	Coded Wire Tag
CZMA	Coastal Zone Management Act
°C	Degrees Celsius
DAH	Domestic Annual Harvest
DAP	Domestic Annual Processing
DCED	Alaska Department of Community and Economic Development
DCPL	Daily Cumulative Production Logbook
DDT	*Para*-dichlorodiphenyltrichloroethane
DFA	Directed Fishing Allowance
DNA	Deoxyribonucleic Acid
DOC	Department of Commerce
DPS	Distinct Population Segment
DSR	Demersal Shelf Rockfish
E	East
EA	Environmental Assessment
EAI	Eastern Aleutian Islands
EA/RIR	Environmental Assessment and Regulatory Impact Review
EBS	Eastern Bering Sea
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EFP	Exempted Fishing Permit
EG	Eastern Gulf of Alaska
EIS	Environmental Impact Statement
EIT	Echo-Integrated-Trawl
EJ	Environmental Justice
ENSO	El Niño - Southern Oscillation
EO	Executive Order
EPA	Environmental Protection Agency
EPAP	Ecosystem Principles Advisory Panel
EPIRB	Emergency Position Indicating Radio Beacons
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
EVOS	*Exxon Valdez* Oil Spill
F	Fishing Mortality Rate
FAO	Food and Agriculture Organization

FEIS	Final Environmental Impact Statement
FEP	Fisheries Ecosystem Plan
FGCV	Fixed Gear Catcher Vessel
FIM	Fisheries Industry Model
FLAT	Flatfish
FLP	Floating Inshore Processor
FMP	Fishery Management Plan
FMU	Fisheries Management Unit
FOCI	Fisheries Oceanography Coordinated Investigation
FPA	Federal Power Act
FR	Federal Register
FRFA	Final Regulatory Flexibility Analysis
ft	Feet/Foot
FT-CP	Fillet Trawl Catcher Processor
FTE	Full-Time Equivalent
FWCA	Fish and Wildlife Coordination Act
FY	Fiscal Year
G&H	Gut-and-Head
GEF	Global Environmental Facility
GFOP	Groundfish Observer Program
GHL	Guideline Harvest Level
GLM	Generalized Linear Model
GOA	Gulf of Alaska
H&L	Hook-and-Line
HACCP	Hazard Analysis and Critical Control Point
HAPC	Habitat Area of Particular Concern
HT-CP	Head-and-Gut Trawl Catcher Processor
HMAP	Halibut Mortality Avoidance Program
I	Insignificant
IAI	Impact Assessment, Incorporated
ID	Identification
IFQ	Individual Fishing Quota
IMALF	Incidental Mortality of Albatross in Longline Fisheries
INPFC	International North Pacific Fisheries Commission
IPHC	International Pacific Halibut Commission
IRFA	Initial Regulatory Flexibility Analysis
IR/IU	Improved Retention/Improved Utilization
ISO	International Organization for Standardization
ISWG	Interagency Seabird Working Group
IUNC	International Union for Conservation of Nature
IWC	International Whaling Commission
JV	Joint Venture
JVP	Joint Venture Processor
kg	Kilogram
KIB	Kodiak Island Borough
km	Kilometer

ACRONYMS AND ABBREVIATIONS (Cont.)

km^2	Square Kilometers
K-SP	Kodiak Shore Plant
L-CP	Longline Catcher Processor
LCV	Longline Catcher Vessel
LL	Lower Limit
LLP	License Limitation Program
LOA	Length Overall
LP	Linear Programming Constrained Optimization Algorithm
m	Meter
MARPOL	International Convention for the Prevention of Pollution from Ships
mb	Millibar
MCA	Marine Conservation Alliance
mi^2	Square Miles
µM	Micrometer
M	Mortality
mm	Millimeter
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Area
MRA	Maximum Retainable Amount
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
mt	Metric Ton
N	North
NAS SF	National Academy of Sciences Policy Recommendations for Sustainable Fisheries
NEPA	National Environmental Policy Act
NFS	Northwest Food Strategies
NFWF	National Fish and Wildlife Foundation
NIOSH	National Institute for Occupational Safety and Health
nm	Nautical Mile
nm^2	Square Nautical Miles
NMFS	National Marine Fisheries Service
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Marine Fisheries Service
NORPAC	NOAA Fisheries Observer Database
NPAFC	North Pacific Anadromous Fish Commission
NPFMC	North Pacific Fishery Management Council
NPFVOA	North Pacific Fishing Vessel Owner's Association
NPI	North Pacific Index
NPO	North Pacific Ocean
NPOA	National Plan of Action
NPRB	North Pacific Research Board
NRC	National Research Council
NS&T	National Status and Trends Program
NSEDC	Norton Sound Economic Development Corporation

NSG	National Standard Guidelines
NTE	Not To Exceed
OCSEAP	Outer Continental Shelf Environmental Assessment Program
OFL	Overfishing Level
OMB	Office of Management and Budget
OPA	Oil Pollution Act
ORCO	Oregon Coast
OSCURS	Ocean Surface Current Simulations
OY	Optimum Yield
PA	Preferred Alternative
PBR	Potential Biological Removal
PCB	Polychlorinated Biphenyl
PCC	Pollock Conservation Cooperative
PCOD	Pacific Cod
P-CP	Pot Catcher Processor
PCV	Pot Catcher Vessel
PFMC	Pacific Fishery Management Council
PICES	North Pacific Marine Science Organization
PLCK	Pollock
POP	Pacific Ocean Perch
PRA	Paperwork Reduction Act
PRD	Protected Resources Division
PRR	Product Recovery Rate
PSC	Prohibited Species Catch
PSG	Pacific Seabird Group
PSMFC	Pacific States Marine Fisheries Commission
PSR	Pelagic Shelf Rockfish
psu	Practical Salinity Unit
PWS	Prince William Sound
QA	Qualitative Analysis
RACE	Resource Assessment and Conservation Engineering
RD	Regional Direction
RFA	Regulatory Flexibility Act
RFMC	Regional Fishery Management Council
RIR	Regulatory Impact Review
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RPN	Relative Population Number
RPW	Relative Population Weight
R/V	Research Vessel
S-	Significantly Adverse
S+	Significantly Beneficial
SAFE	Stock Assessment and Fishery Evaluation
SC-SP	Southcentral Alaska Shore Plant
SEBSCC	Southeast Bering Sea Carrying Capacity
SEIS	Supplemental Environmental Impact Statement

SEO	Southeast Outside
SE-SP	Southeast Alaska Shore Plant
SFA	Sustainable Fisheries Act
SIAWG	Seabird Inter-Agency Working Group
SoC	Secretary of Commerce
SP	Shore Plant
SPELR	Shoreside Processor Electronic Logbook Report
SPR	Spawning Biomass Per-Recruit
SSC	Scientific and Statistical Committee
SSL	Steller Sea Lion
ST-CP	Surimi Trawl Catcher Processor
STWG	Seabird Technical Working Group
TAC	Total Allowable Catch
TALFF	Total Allowable Level of Foreign Fishing
TCV	Trawl Catcher Vessel
U	Unknown
UL	Upper Limit
U.S.	United States
USGS	U.S. Geological Survey
U.S.S.R.	Union of Soviet Socialist Republics (Soviet Union)
USC	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USGS/BRD	U.S. Geological Survey/Biological Resource Division
VDE	Voluntary Dockside Examination
VIP	Vessel Incentive Program
VMP	Vessel Monitoring Program
VMS	Vessel Monitoring System
W	West
WAIW	Washington Inland Waters
WG	Western Gulf of Alaska
WPR	Weekly Production Report
WSGP	Washington Sea Grant Program
YDFDA	Yukon Delta Fisheries Development Association

GLOSSARY

abiotic: not living.

acceptable biological catch (ABC): the range of allowable catch for a species or species group set by a scientific calculation of the sustainable harvest level of a fishery; a target reference point that management aims to achieve.

advection: horizontal or vertical movement of a mass of fluid, i.e. air or ocean current.

advisory panel (AP): a group of people appointed by a fisheries management agency to review information and give advice. Members are usually not scientists, but most are familiar with the fishing industry or a particular fishery.

alcids: small birds that fly with rapid wing beats and use their wings to swim underwater.

Alaska Coastal Current: a persistent flow of buoyant water circumscribing the inner shelf of the Gulf of Alaska shelf over 2000 km from its origin in the southeastern Gulf of Alaska to where it enters the Bering Sea in the southwestern gulf.

Alaska Current: the shallow, highly variable, eastern limb of the counterclockwise-flowing subpolar gyre in the North Pacific

Alaska Stream: the steady, swift current that flows westward approximately 150 km from the coast and reaches to the ocean floor.

albedo: the fraction of light radiation that is reflected by a body, as the moon or a cloud.

alkanes: any of numerous saturated, non-aromatic hydrocarbons; any of a series of open-chain hydrocarbons such as methane and butane.

American Fisheries Act (AFA): enacted 1998, this act requires the determination of whether vessels of 100 feet or greater in registered length comply with the new ownership, control and financing requirements imposed, thereby demonstrating eligibility to receive a fishing endorsement.

amphipods: small crustaceans with flat bodies.

anadromous: fish that migrate from saltwater to fresh water to spawn.

anal fin: the fin that lies behind the anus, usually on the back half of the fish.

annelids: long, segmented invertebrates that have a coelom. (e.g., earthworms, various marine worms, and leeches).

anomalous: inconsistent with or deviating from what is usual, normal, or expected.

anoxic: oxygen deficient.

anthropogenic: of or relating to the study of the origins and development of human beings.

anthozoans: sessile marine coelenterates including solitary and colonial polyps; the medusoid phase is entirely suppressed.

apex feeders: those who feed at the top of the food chain.

appendicularia: free-swimming tadpole-shaped tunicate resembling larvae of other tunicates.

aromatic hydrocarbons: a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances.

arthropods: invertebrate animals such as crabs that have segmented bodies and jointed appendages, and an exoskeleton.

austral winter: winter in the southern hemisphere.

avian: pertaining to or characteristic of birds.

avifauna: the birds of a region or environment.

B: see *biomass*.

B_0: biomass at the starting point of a population at its original or pristine level.

B_{MSY}: the average biomass that would be achieved if fishing continued at a constant fishing mortality rate resulting in the maximum sustainable yield.

barnacle: a marine crustacean with feathery appendages for gathering food, free-swimming as larvae but permanently fixed (as to rocks, boat hulls, etc.) as an adult.

baroclinic: a state in which water surfaces of equal density are influenced by those of equal pressure.

barotropic: a water state in which surfaces of pressure and density coincide at all levels; depth-independent circulation due to changes in surface elevation.

basal metabolic rate: the rate at which heat is given off by an organism at complete rest.

bathyal: refers to organisms or phenomena at depths between 200 & 4000 meters, on the sea bottom; often coincident with the continental slope.

Bathylagidae: Family of fishes in the Class: Actinopterygii; distribution includes the Atlantic, Indian and Pacific Oceans. Physical characteristics include: Adipose fin may be present or absent.

bathylagids: deep-sea smelts.

bathymetric: water depth measurement.

benthic: portion of the marine environment inhabited by marine organisms that live permanently in or on the bottom.

benthic substrate: the base on which an organism lives.

benthypelagic: suspended in the water column near the bottom.

GLOSSARY (Cont.)

benthos: organisms that live on or in the bottom of a body of water.

Bering Sea Gyre: a barotropic, counterclockwise gyre of the Aleutian Basin.

Bering Slope Current: a counter-clockwise flow with an eastern boundary current at the shelf edge

biennial: occurring every second year.

bioaccumulation: an increase in the concentration of a chemical in a biological organism over time, compared to the chemical's concentration in the environment.

biogenic: produced by living organisms.

biomarker: a distinctive usually biochemical indicator of a biological or geochemical process or event.

biomass (*B*): amount of living matter per unit of water surface or volume expressed in unit weight .

biota: all the plant and animal life of a particular region.

biotic: living or related to living units.

biphenyls: a white crystalline hydrocarbon used especially as a heat-transfer medium ($C_6H_5 \cdot C_6H_5$.)

bivalve: having a shell composed of two valves.

boreal: of or located in northern regions.

brash ice: floating ice found between the year's first ice floes and made up of fragments from other ice forms.

bryozoan: one of a phylum of minute, mostly colonial aquatic animals, with body walls often hardened by calcium carbonate and growing attached to aquatic plants, rocks and other firm surfaces.

butyltins: organic tin compounds in either single, double, or triple forms and used to inhibit the growth of unwanted organism such as bacteria, algae, and barnacles.

bycatch: harvested species other than that for which the fishing gear was set. Also called *incidental catch*, bycatch is sometimes kept for sale (does not include fish released alive under a recreational catch-and-release program).

°C: degrees Celsius.

calanoid (e.g., copepod): large copepod easily recognized by its longer-than-body antennae.

California Current: the eastern limb of the clockwise flowing subtropical gyre in the North Pacific.

cannibalistic: the eating of the flesh of an animal by another animal of the same kind.

caprellid: a species of amphipods commonly known as skeleton shrimp.

carapace: a bony case or shield covering the back or part of the back of an animal as a turtle or crab.

caridean: a group belonging to the crustaceans, commonly known as shrimp.

carrion: dead flesh that is unfit for food.

cartilaginous: composed of cartilage.

catch: the total number or poundage of fish captured from an area over some period of time, including fish that are caught but released or discarded instead of being landed.

catch per unit of effort (CPUE): the quantity of fish caught with one standard unit of fishing effort; e.g. the combination of gear type, gear size, and length of time gear is used. Also used as a measurement of relative abundance for a particular fish.

caudal: at the hind or tail end of the body.

caudal fin: the terminal fin, or tail, of a fish.

caveat: an explanation to prevent misinterpretation.

central Pacific Gyre: this gyre is bordered by the southern flowing, cold water California current which runs into the western moving, warm water North Equatorial Current. The North Equatorial Current moves north with the Philippines Current and then northeast into the Kuroshio Current. West winds push the North Pacific current east where it divides at the North American continental plate to form the Alaska Current to the north (part of the North Pacific gyre) and the California Current to the south. This is a clockwise moving gyre.

cessation: end, cease, stop.

cetaceans: aquatic, mostly marine, mammals including whales, dolphins, porpoises, and others that have a torpedo shaped, nearly hairless body, paddle-shaped forelimbs, no hind limbs, one or two nares opening externally at the top of the head, and a flat tail for locomotion.

chaetognath: small free-swimming marine worms with movable curved chaetae on either side of the mouth.

chlordane: a highly chlorinated viscous volatile liquid insecticide ($C_{10}H_6Cl_8$).

chrysene: one of the polycyclic aromatic hydrocarbon compounds formed when gasoline, garbage, or any animal or plant material burns. Usually found in smoke and soot, this chemical combines with dust particles in the air and is carried into water and soil and onto crops.

circumpolar: constantly visible above the horizon.

cladoceran: minute chiefly freshwater branchiopod crustaceans that includes the water fleas.

coastal lowland: a narrow strip of relatively low ground between the sea and the cliffs leading to the plateau with a climate wetter than that of the plateau; with fewer temperature extremes it is more subject to fog.

coastal runoff: land-based pollution, i.e., chemicals and other contaminants that make their way into coastal waters.

coccolithophorid: the unicellular marine plant plankton with a calcareous skeleton that form the base of the food chain.

community development quota (CDQ): a federal fisheries program that involves coalitions of communities who have formed six regional organizations. The program allocates a portion of the Bering Sea and Aleutian Island harvest amounts to groups.

concomitant: accompanying, especially in a subordinate or incidental way.

congener: a member of the same taxonomic genus as another plant or animal; something resembling another in nature or action.

continental shelf: a shallow submarine plain of varying width forming a border to a continent and typically ending in a steep slope to the ocean floor.

continental slope: the usually steep slope from a continental shelf to the ocean floor.

control rule: describes a variable over which management has some direct control as a function of some other variable(s) related to the status of the stock.

copepods: a group of small crustaceans, some free-swimming and some parasitic on fish gills or skin.

cottid: member of the family Cottidae, which includes sculpin and bullhead.

covariance: the expected value of the product of the deviations of two random variables from their respective means.

crangonid shrimp: commonly called bay shrimp; there are three species in the Family Crangonidae.

critical habitat: a specific area that is necessary for preservation of a threatened or endangered species that may require special protection or management.

crustacean: a group of freshwater and saltwater animals having no backbone, with jointed legs and a hard shell made of chitin.

ctenophore: marine animals superficially resembling jellyfishes but having biradial symmetry and swimming by means of eight meridional bands of transverse ciliated plates.

cumacea: an order of marine crustacea, mostly of small size.

cycloalkanes: alkanes in which at least one of the continuous carbon chains is linked back on to itself in the form of a ring.

davit: a crane that projects over the side of a ship or hatchway and is used for boats, anchors, or cargo.

decapod: crustaceans with five pairs of thoracic appendages one or more of which are modified into pincers, with stalked eyes, and with the head and thorax fused into a cephalothorax and covered by a carapace; cephalopod mollusks with 10 arms.

deep water basin: a collection of water so deep that surface waves are little affected by the ocean bottom; generally characterized as water deeper than one-half the surface wavelength.

demersal: living near the bottom of a water body.

density-dependent mortality: increased risk of death associated with increased population density.

denticulate: fine toothed or serrated.

depredation: to lay waste; to plunder.

depth strata: (also known as depth zone) any of one of the four oceanic environments: the littoral, neritic, bathyal and abyssal zones.

detritus: loose material (organic particles) resulting from disintegration.

diatoms: minute planktonic unicellular or colonial algae with silicified skeletons.

dibenzothiophenes: a polynuclear aromatic hydrocarbon; an environmental hazard.

dinoflagellate: chiefly marine phytoplanktonic, usually solitary unicellular flagellates that include luminescent forms and forms that cause red tide.

diurnal: having a daily cycle; occurring in the daytime.

domestic annual harvest (DAH): the domestic annual fishing capacity, modified by other factors (such as economic factors), which will determine estimates of what fishing fleets will harvest.

domestic annual processing (DAP): the amount that will be domestically processed, based not only on physical capacity but on a demonstrated intent and the effects of domestic harvesting, markets, and other fisheries.

donut hole: an area which encompasses approximately 48,000 square miles and comprises 19 percent of the Aleutian Basin or 10 percent of the entire Bering Sea area where the stocks being fished are suspected to straddle or move back and forth across the open area and an area of regulated national jurisdiction.

dorsal: the back of the body.

dorsal fin rays: cartilaginous structures within the dorsal fin.

downwelling: a circulation pattern in which warmer surface waters move down in the water column.

echinoderms: marine animals including starfishes, sea urchins, and related forms.

Echiuroid worm: marine worms that have sensitive but non-retractable proboscis above the mouth.

ecosystem: the community of living creatures occurring in an environment.

El Niño Southern Oscillation: an interannual disturbance of the climate system characterized by a periodic weakening of the tradewinds and warming of the surface layers in the equatorial Pacific Ocean every 4 to 7 years.

embayment: a small bay or semi-enclosed coastal water body whose opening to a larger water body is restricted.

endemic: native to a particular country; characteristic of or prevalent in a particular environment.

endocrine system: the system of glands/organs capable of secreting hormones which provide communication in the body

epibenthic: living on the surface of bottom sediments in a water body.

epifauna: invertebrates living on to of the sediment of the seafloor.

epipelagic: the zone of the ocean into which enough light penetrates for photosynthesis.

errantiate: form of the word "errant" meaning to move or wander, usually an irregular motion.

escarpment: a long cliff or steep slope separating two comparatively level or more gently sloping surfaces and resulting from erosion or faulting.

estuary(ies): a water passage where the tide meets a river current.

eunicid: a family belonging the to the Polychaetes, characterized by having up to five antennae and pincher-like jaw maxilla.

euphausiid: small, pelagic, shrimp-like crustaceans, e.g., krill.

euphotic: constituting the upper layers of a body of water where sufficient light penetrates to permit green plant growth.

ex-vessel: activities that occur when a commercial fishing boat lands or unloads a catch.

exclusive economic zone (EEZ): a zone under national jurisdiction (up to 200-nautical miles wide) within which the coastal State has the right to explore, and the responsibility to conserve and manage, the living and non-living resources.

exogenous: due to external causes; not arising within the organism.

extrapolate: to infer (values of a variable in an unobserved interval) from values within an already observed interval.

extrude: to force out.

F_{MSY}: a continuous fishing mortality rate that results in the maximum sustainable yield.

$F_{\%SPR}$: the fishing mortality rate associated with a stable spawning per recruit level equal to X% of the spawning per recruit level at equilibrium when no fishing has occurred.

faunal: being animal life.

fecundity: the measure of the egg-producing ability of a fish..

filter feeder: an animal that obtains food by filtering organic matter or minute organisms from a current of water passing through some part of its system.

fishery: as defined by the Magnuson-Stevens Fishery and Conservation Act, a fishery is one or more stocks of fish that can be treated as a unit for purposes of conservation and management and that are identified on the basis of geographic, scientific, technical, recreational, or economic characteristics.

fishery management plan (FMP): a plan developed by a regional fishery management council, or by the U.S. Secretary of Commerce, to manage a fishery resource to achieve specified management goals.

fishing mortality rate (F): a measurement of the rate of removal of fish from a population by fishing. Expressed as either "annual" or "instantaneous rates;" annual mortality if the percentage of fish dying in one year while instantaneous mortality is the percentage of fish dying at any one time.

fjord: a narrow inlet between cliffs or steep slopes.

fledge: to rear until ready for flight or independent activity.

foraminiferan: marine protozoans usually having calcareous shells that are perforated with minute holes for protrusion of slender locomotors or food gatherers.

forage fish: any fish eaten by larger predatory fish, seabirds, or marine mammals, usually swimming in large schools.

fossil fuel: a fuel (as coal, oil, or natural gas) that is formed in the earth from plant or animal remains.

fry: recently hatched or juvenile fish.

gadoid fish: resembling or related to the cods.

gammarid: a family belonging to the amphipods

gastropods: a large group of mollusks including the snails.

genus (plural, genera): a class or group marked by common characteristics.

gladius: the internal shell, or pen, of cephalopods like squid.

glaucous: of a pale yellow-green or a light bluish-gray or bluish-white color.

gorgonian: an anthozoan with a horny and branching axial skeleton.

gradient: the rate of regular or graded ascent or descent; part sloping upward or downward; change in the value of a quantity (temperature, pressure, or concentration) with change in a given variable.

greenhouse gases: gases that contribute to the greenhouse effect by trapping heat within the earth's atmosphere. The chief greenhouse gases are carbon dioxide and water vapor. Other potentially important trace gases are chlorofluorocarbons, methane, ozone, and nitrous oxide.

gregarious: tending to associate with others of one's kind.

groundfish: a species or group of fish that lives most of its life on or near the sea bottom.

guild: a group of species that utilize the same kinds of resources, such as food, nesting sites, or places to live, in a similar manner.

guild diversity: the variation in the number of species that share a common food source.

gyre: a giant circular oceanic surface current.

halocline: a usually vertical gradient in salinity.

harpacticoid copepods: minute crustaceans, often long and cylindrical in shape.

harvest: the total number or poundage of fish caught and kept from an area over a period of time.

holoplanktonic: living in the water column.

harpacticoid: a family belonging to the copepods.

haulout: a resting place.

hydroacoustic: sound waves bounced off the ocean floor.

hydrocarbon: an organic compound containing only carbon and hydrogen and often occurring in petroleum, natural gas, coal, and bitumens.

hydroid: of or relating to a hydrozoan; especially resembling a typical hydra.

hyperiid: a family belonging to the amphipods.

ichthyoplankton: fish eggs or larvae.

incidental catch: see *bycatch*.

indigenous: having originated or naturally occurring in a particular region or environment.

individual fishing quota (IFQ): a federal permit under a limited access system to harvest a quantity of fish, expressed by a unit or units representing a percentage of the total allowable catch of a fishery that may be received or held for exclusive use by a person.

infauna: invertebrates living in the sediment of the seafloor.

inflow: the flowing in [of air].

in situ: in the natural or original position or place.

instantaneous mortality: see *natural mortality*.

intertidal: relating to or being the part of the littoral zone above low-tide mark.

intra-annual: occurring during or within a year time span.

invertebrate: any animal lacking a spinal column.

isobath: a line of a map passing through all points of equal depth below water.

isomer: one of two or more compounds or ions that contain the same number of atoms of the same elements but differ in structural arrangement and properties.

isopod: a small crustacean with attached eyes and a body composed of seven free thoracic segments each bearing a pair of similar legs.

isotope: two or more species of atoms in a chemical element with the same atomic number and nearly identical chemical behavior but with differing atomic masses and different physical properties.

juvenile: a young fish or animal that has not reached sexual maturity.

kamaboke: white fish filleted and pounded into a paste.

Kamchatka Current: a current which brings water southward from the Bering Sea, where it is associated with the quasi-permanent anticyclonic eddies found close to the western shore.

kinetic energy: energy associated with motion.

kirimi: a fish processing style in which the head and tail are taken off and the guts are left in the fish.

landings: the number or poundage of fish unloaded at a dock by commercial fishermen or brought to shore by recreational fishermen for personal use.

larvaceans: small transparent animals found in marine plankton, e.g., tunicates

License Limitation Program (LLP): a limited access program intended to limit participation in the groundfish fisheries in the Gulf of Alaska and the Bering Sea and Aleutian Islands federal management areas and Bering Sea and Aleutian Islands crab fisheries based on past documented harvests made by each fishermen.

limit reference points: limits (e.g., OFL, MFMT) established by management to be avoided, constrains harvests so that the stock remains within safe biological limits.

littoral: of, relating to, or situated or growing on or near a shore. Or, a coastal region, especially the shore zone between high and low watermarks.

M: see *natural mortality*.

macrofauna: small to moderate sized invertebrates living on and in bottom sediments.

macrozooplankton: large, thick, or exceptionally prominent animal life of the plankton.

Magnuson-Stevens Fishery Conservation and Management Act: a federal law that created the regional councils and is the federal government's bases of fisheries management in the EEZ (U.S. Public Law 94-265, as amended through October 11, 1996).

marine mammal: animals that live in marine waters and breathe air directly, i.e., sea lions, porpoises, whales, and seals.

maximum fishing mortality threshold (MFMT): standard determination criteria for determining if overfishing is occurring within a stock; equivalent to OFL in the BSAI and GOA FMPs.

maximum sustainable yield (MSY): the largest average catch or yield that can continuously be taken from a stock under average environmental conditions.

medusae: jellyfish.

meiofauna: benthic animals that can fit a mesh size of 1 millimeter and be retained on a mesh size of 42 micrometers.

Meridional thermal gradient: the vertical (north-south) flow of water of which the surface is made up of warm waters underlain by deep cold waters.

mesopelagic region: relating to oceanic depths from about 600 feet to 3000 feet (200 to 1000 meters).

metabolite: substances which are required as basic raw materials for vital processes, such as glucose in respiration and other metabolic pathways.

meteorological regime: circulation air mass.

metric ton: 2,204.62 pounds.

microflora: minute plants not seeable with the naked eye.

micronekton: microscopic free-swimming aquatic animals that move independent of wave and current action.

millimeter (mm): ½5 of an inch.

milt: the sperm-containing fluid of a male fish.

minimum stock size threshold (MSST):a standard determination criteria used for determining when a stock is in a overfished condition; usually measured in terms of spawning biomass.

mollusk: an invertebrate animal with a soft unsegmented body usually with one or two hard shells made of calcium carbonate.

molt: to periodically shed hair, feathers, shell, horns, or other outer layer.

morphological: an organisms form and structure.

MSY control rule: a harvest strategy that results in a long-term average catch approximating MSY, enables the use of proxies.

multispecies perspective: a management theory that recognizes the interactions between organisms, for example: predator-prey relationships.

munid crabs: crustaceans belonging to the Family Galathoidae.

myctophids: members of the Family Myctophidae.

Myctophidae: deep sea fishes comprising the lantern fishes.

mysids: small, shrimp-like marine crustaceans, the females of which carry their eggs in a pouch beneath the thorax.

naphthalene: a crystalline aromatic hydrocarbon ($C_{10}H_8$) usually obtained by distillation of coal tar and used especially in organic synthesis.

natal area: area associated with birth.

National Standard Guidelines: seven FMP guidelines and standards required by MSFCMA to identify the nation's interest in fish management.

natural mortality rate (*M*): a measurement of fish deaths from all causes other than fishing such as predation, disease, starvation, and pollution.

nauplius (plural, nauplii): a crustacean larva usually in the first stage after leaving the egg and with three pairs of appendages, a median eye, and little or no segmentation.

nautical mile: 6,076.115 feet or 1,852 meters.

near-shore eddy(ies): inshore waters that run contrary to the current.

Near Strait Inflow: the primary source of inflow in the Bering Sea.

necropsy: an examination of an organism after death to determine the cause of death or the character and extent of changes caused by disease.

necrotic: localized death of living tissue.

nematode: elongated cylindrical worms parasitic in animals or plants or free-living in soil or water.

neoplasia: formation of tumors

neritic: region of shallow water adjoining the seacoast.

nocturnal: active at night.

nodal: being or located at or near a node. In a tide area, the point about which the tide oscillates and where there is little or no rise and fall of the tide.

Nor'eastern: a trawl constructed with polyethylene mesh and outfitted with other types of footropes for the Gulf of Alaska, the Aleutian Islands, and the Pacific West Coast shelf surveys, has a 27.2 meter headrope, and a 37.4 meter footrope; the body is 127 millimeter stretched mesh and the codend is 89 millimeter stretched mesh with a 32 millimeter stretched mesh codend liner; floats along the headrope hold the net open vertically.

North Pacific Index: the area-weighted sea level pressure over the North Pacific in the region 30°N to 65°N, 160°E to 140°W.

nuclide: species of atom characterized by the constitution of its nucleus and hence by the number of protons, the number of neutrons, and the energy content.

σ_t: a measure of the density of water, at its current pressure, if it were raised to the surface.

Ocean Current simulations model: ocean simulations models may input climate data, ocean circulation, sea-ice, temperature gradient, nutrient gradient, anthropogenic events and large climatic events (e.g. ENSO) among other information to better understand how the ocean works and predict weather events and possible human impacts on ocean systems (among other uses).

oceanographic: pertaining to the ocean.

offal: the waste or by-product of a process; debris, garbage, etc.

oikopleura: a small pelagic tunicate at the basis of the chordate phylum; larvaceans.

ommatidia: the structural elements forming the compound eye of arthropods, insects, etc.

omnivorous: feeding on both animals and vegetables.

ontogeny: the development or course of development of an individual organism.

onuphid: beachworm; a member of the family Onuphidae

optimum yield (OY): the harvest level for a species that achieves the greatest overall benefits, including economic, social, and biological considerations.

ostracods: very small, active, mostly freshwater crustaceans that have the body enclosed in a bivalve shell, the body segmentation hidden, the abdomen rudimentary, and only seven pairs of appendages.

overfished: a stock or stock complex whose size is sufficiently small that a change in management practices is required in order to achieve an appropriate level and rate of rebuilding; a stock is determined to be overfished when it is below the minimum stock size threshold.

overfishing: a rate or level of fishing greater than that which will meet the management goal and that jeopardizes the capacity of a fishery to produce the largest average catch or yield that can continuously be taken under average environmental conditions on a continuing basis.

overfishing level (OFL): a fishing rate that reduces the level of spawning biomass per recruit to some percentage of its original, pristine level; a limit reference point that management seeks to avoid.

overwintering: surviving the winter.

ovoviviparous: producing eggs that develop within the maternal body and hatch within or hatch immediately after being pushed out from the parent.

Pacific decadal oscillations: an El Niño-like pattern (see previous) of Pacific climate variability and persisting for 20 to 30 years with climatic fingerprints most visible in the North Pacific/North American sector.

panmictic: mating randomly.

parturition: the action of giving birth to offspring.

pelagic: refers to fish and animals who live in the open sea, away from the sea bottom.

per capita: per unit of population.

perylene: an organic molecule consisting of 20 carbon atoms and 12 hydrogen atoms arranged as five benzene-like rings connected to each other in a plane.

phenanthrenes: a crystalline aromatic hydrocarbon ($C_{14}H_{10}$) of coal tar isomeric with anthracene.

phyla: primary division of the animal kingdom.

phytoplankton: planktonic plant life.

pinniped: an aquatic carnivorous animal with all four limbs modified into flippers.

piscivorous: feeding on fishes.

planktivorus: feeding on plankton.

plankton: the passively floating or weak swimming animal and plant life of a body of water.

planktonic: of or relating to plankton

pleuronectid: pertaining to the flounder family.

polychaete: chiefly marine annelid worms, i.e., clam worms, usually with paired segmental appendages, separate sexes, and a free-swimming trochophore larva.

polychlorinated: PCB - any of several compounds that are produced by replacing hydrogen atoms in biphenyl with chlorine, have various industrial applications, and are poisonous environmental pollutants which tend to accumulate in animal tissues.

polycyclic: having more than one cyclic component, i.e. having two or more rings in the molecule.

polynias: see polynyas.

polynya(s): open water in sea ice.

population: fish of the same species inhabiting a specified area grouped together for management purposes.

predation: the act of preying or plundering; a mode of life in which food is primarily obtained by the killing and consuming of animals.

pre-neoplastic: pre-malignant.

probability density function: a statistical distribution; used in deriving overfishing limits and acceptable biological catch.

procellarid: one of a family of oceanic birds (Procellarid[ae]) including the petrels, fulmars, and shearwaters.

procellariiformes: tube-nosed swimmers, fulmars and albatrosses.

prohibited species catch (PSC): in applicable Bycatch Limitation Zones of the Bering Sea subarea - limits specified for red king crab, Chionoecetes bairdi Tanner crab, and C. opilio crab; throughout the BSAI - limits specified for Pacific halibut and Pacific herring. Regulations authorize the apportionment of each limit into allowances for specified fishery categories. Seven-and-a-half percent of each limit specified for halibut, crab, and salmon is reserved as a quota for use by the CDQ program.

protease: any of numerous enzymes that hydrolyze proteins.

protobranch: a gill structure occurring in bivalves in which gills are small and leaf like with the unmodified appearance occurring in primitive groups.

protozoan: minute cell-less or one-celled animals that often have complex life cycles and frequently are serious parasites to humans and other animals.

protracted spawning: a longer spawning period.

proxy: a substitution; something that is authorized to act in place of another.

pterpods: small mollusks that expand the front lobes of the foot into thin wing-like organs with which they swim.

pyrogenic: caused by or generating heat.

pteropod: holoplanktonic molluscs belonging to the orders of Thecosomata and Gymnosomata. The species have in common that the original foot has developed into a pair of 'wings' (parapodia), increasing the animals' buoyancy and locomotion capacity.

pycnocline: a layer in the water column separating two areas of different density.

quota: the maximum number of fish that can be legally landed in a time period.

radiolarian: spherical marine protozoans having radiating threadlike protrusions for locomotion or food gathering and often a siliceous skeleton of spicules.

radionuclide: a radioactive nuclide.

rebuilding plan: a plan that is designed to recover stocks when they are overfished.

recruit: an individual fish that has moved into a certain class, such as the spawning class or fishing-size class.

recruitment: a measure of the weight or number of fish that can enter a defined portion of stock, such as the fishable stock or the spawning stock, during some time period.

reef: a chain of rocks or coral or a ridge of sand at or near the surface of water or within a depth of 20 meters from the surface..

reference points: limits or values that are used to guide management decisions.

regime shift: a transition from one climactic state to another within a period substantially shorter than the lengths of the individual epochs of each of the two climatic states.

regulatory impact review (RIR): the part of a federal fishery management plan that describes the impacts resulting from the plan.

rip (also tide rip): agitation of water caused by the meeting of currents or by a rapid current setting over an irregular bottom. Termed tide rip when a tidal current is involved.

risk averse: avoiding risk.

roe: the eggs of a fish especially when still enclosed in the ovarian membrane.

rookery: the nest, haunt, or breeding ground of a colony, especially of gregarious birds or mammals.

salpa: a transparent barrel-shaped or fusiform free-swimming tunicate that is abundant in warm seas.

satiation: full or excessive satisfaction.

seamount: elevation rising 1000 meters or more from the sea floor and of limited extent across the summit.

sediment: matter that settles to the bottom; material deposited by water, wind, or glaciers.

serpulid: a small marine annelid worm which build limey tubes on stones and seaweed and extends a crown of tentacles to feed.

semidemersal: semi-bottom-dwelling.

sessile: permanently attached at the base or foot.

sideboard measures: constraints imposed on a directed fishery that restrict its participation in other directed fisheries.

sill fjord: natural rock barriers occurring at the mouth of a fjord and delineating the extent of the progress of the glacier that carved the fjord.

siphonophores: compound free-swimming or floating pelagic hydrozoans that are mostly delicate, transparent, and colored and have specialized zooids.

spatial dispersion: a movement over space or area.

spawning per recruit (SPR): amount of spawning biomass at a instantaneous fishing mortality rate, influenced by other values including growth, maturity, natural mortality and partial recruitment.

spermatheca: a sac for sperm storage in the female reproductive tract of many lower animals.

spermatophore: a capsule, packet, or mass enclosing spermatozoa extruded by the male and conveyed to the female in insemination.

standard determination criteria: criteria (e.g., MSST, MFMT) used to determine if a stock is in a overfished state, according to the National Standard Guidelines.

stalked ascidians: sea tulips.

steranes: organic molecules with 26 to 30 carbon atoms arranged in four rings.

stock or stock complex: a grouping of fish usually based on genetic relationship, geographic distribution, and movement patterns.

stock assessment: a means of estimating fish numbers and predicting how fish populations will respond to harvesting.

Stock Assessment and Fishery Evaluation Report (SAFE): a report that provides a summary of the most recent biological condition of a stock of fish as well as the economic and social condition of the recreational fishermen, commercial fishermen, and seafood processors who use the fish. It is used to determine harvest levels.

stratum: a sheet like mass of sedimentary rock or earth of one kind lying between beds of other kinds; a region of the sea or atmosphere that is analogous to a stratum of the earth.

subarctic: characteristic of, or being regions immediately outside of the arctic circle or regions similar to these in climate or conditions of life.

Subarctic Current: the current which flows eastward from the western Rim of the Pacific Ocean.

sublittoral: benthic region extending from mean low water to a depth of about 200 meters or to the edge of the continental shelf. Situated, occurring, or formed on the aquatic side of a shoreline or littoral zone.

subtidal: the zone that is permanently flooded by tidal water.

surimi: fish product made from inexpensive whitefish and often processed to resemble more expensive seafood (i.e., crabmeat).

Sustainable Fisheries Act (SFA): an amendment to the Magnuson-Stevens Fishery Conservation and Management Act which includes numerous provisions requiring science, management, and conservation action by NMFS.

target reference points: limits and benchmarks (e.g., ABC) to be achieved, but not exceeded, by management.

taxa: a category or group of related organisms.

taxonomic: classification of plants and animals according to their presumed natural relationships.

telemetry: the science of automatic data measurement and transmission of data.

teleost: a group consisting of fishes with bony skeletons and rayed fins.

temperate: marked by moderation; not extreme or excessive.

terrestrial: of or related to earth and its inhabitants.

terrigenous: relating to oceanic sediment derived directly from destruction of surface rock.

thermal stratification: horizontal layers of differing densities produced in a lake by temperature changes at different depths.

thermocline: the region in a thermally stratified body of water which separates warmer oxygen-rich surface water from colder oxygen-poor deep water and in which temperature decreases rapidly with depth.

thermoregulation: the maintenance or regulation of temperature, i.e., body temperature.

tide rip: see *rip*.

Tier: each stock or stock complex is categorized into a certain "tier" or level based on the amount of information available for the given stock or stock complex. From these tiers, certain limits are derived using mathematical equations.

tintinnid: marine plankton

topography: the configuration of an earth surface including its relief and the position of its natural and man-made features.

total allowable catch (TAC): the annual recommended catch for a species or species group. Set from the range of acceptable allowable catch.

Total Allowable Level of Foreign Fishing (TALFF): that portion of the optimum yield which will not be harvested by domestic vessels. The foreign allowable catch is determined by deducting the expected domestic annual harvest and reserve from the optimum yield (TALFF = OY- [DAH + reserve]).

triennial: occurring every three years.

triterpanes: pentacyclic biological marker hydrocarbons containing between 27 and 35 carbon atoms.

trophic: ecology of or involving the feeding habits or food relationship of different organisms in a food chain.

trophic level: a group of organisms that occupy the same position in a food chain.

trophic guild: a group of species which use similar resources (e.g. insectivorous birds are a trophic guild of birds that eat insects).

tunicate: marine chordate animals with a thick secreted covering layer, a greatly reduced nervous system, a heart able to reverse the direction of blood flow, and only in the larval stage a notochord.

turrid: a family of snails, now reclassified into several subfamilies.

ubiquitous: existing everywhere at the same time; constantly encountered.

µM: micrograms per liter.

uncertainty: a lack of perfect knowledge. Rosenberg and Restrepo (1994) identify five types of uncertainty: 1) measurement error, 2) process error, 3) model error, 4) estimation error, and 5) implementation error.

upwelling: the process by which water rises from a deeper to a shallower depth, usually as a result of offshore surface water flow; it is most prominent where persistent wind blows parallels to a coastline so that the resultant Ekman transport moves surface water away from the coast..

uterine cannibalism: while still in the mother's reproductive tract, the first hatchling eats either younger `hatchlings or unfertilized eggs to get nourishment.

vertebrate: having a spinal column.

vestigial: sign or evidence of some past thing.

viviparous: producing living young rather than eggs.

voracious: having a ravenous appetite.

vorticity: a swirling motion.

West Wind Drift: (also known as Antarctic Circumpolar Current) the ocean current from west to east through all the oceans around the Antarctic continent.

wind-stress curl: the plot of the energy transferred from the wind to the sea surface.

year-class: the fished spawned and hatched in a given year; a "generation" of fish.

young-of-the-year: fish or animals born in the past year, which have not yet reached one year of age.

zooplankton: plankton composed of animals.

Chapter 4

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Chapter 4 Environmental and Economic Consequences

This Programmatic Supplemental Environmental Impact Statement (SEIS) has so far presented the preliminary information necessary to analyze the potential impacts resulting from implementation of any of the five policy alternatives (Alternatives 1-4, plus the North Pacific Fishing Management Council's [NPFMC] Preferred Alternative). We have explained the purpose and need for federal action (Chapter 1) and reviewed both the legal context of federal fisheries management in Alaska and the tools managers use to satisfy those legal requirements (Chapter 2); also in Chapter 2, we defined the alternatives presented in this document and the Fishery Management Plan (FMP) bookends created to illustrate the range of management measures that might be used to implement a given policy alternative; and, in Chapter 3, we defined the environmental and economic baseline conditions against which the impacts of the alternatives can be measured.

We now turn to the work of analyzing the possible impacts of the alternatives. Chapter 4 presents our analysis of the FMP bookends and the environmental and economic impacts that might reasonably be expected to follow from implementation of the suite of management measures contained in each FMP bookend. The analyses contained in this chapter will thus allow readers to evaluate the relative effectiveness of the policy alternatives in meeting the legal, environmental, and economic demands of the federal groundfish fisheries off Alaska.

Analysis of the impacts of management policies requires knowledge of potential actions that could be taken to implement the policy. Policies are, by definition, a high-level, overall statement or plan embracing the general goals and procedures of a government body. In the United States (U.S.), policies usually reflect the values and wisdom of the citizens, as expressed by laws and agencies of the nation. Policy goals and objectives are often used to frame the policy and make the statement clearer and easier to understand. Still, determination of the effects of a policy on the human environment is difficult to comprehend and analyze without some indication of how the policy might be implemented.

This chapter evaluates a number of example FMPs intended to illustrate a particular policy as defined by the alternatives described in Section 2.6. In evaluating example FMPS, we will be able to better understand the current management policy governing federal management of the groundfish fisheries off Alaska, as well

as the trade-offs of changing existing policy to reflect a new management approach. Since we had no proposed alternative management policies or alternative FMPs to consider at the outset of the Programmatic SEIS process, National Marine Fisheries Service (NMFS or national Oceanic and Atmospheric Administration [NOAA] Fisheries) has relied heavily on comments received during the public scoping process and on the 2001 Draft Alaska Groundfish Fisheries Programmatic SEIS in crafting the alternatives. Additionally, NOAA Fisheries consulted frequently with the NPFMC in developing the alternatives by relying on their expertise and judgement.

Significant changes to the structure and organization of this chapter have been made in response to public comments on the 2001 Draft Programmatic SEIS. As we explained in Chapter 2, we have restructured the policy alternatives to better reflect a multi-species, ecosystem management approach. Each of the policy alternatives (Alternatives 1 through 4) now represents a different management approach, ranging from a more aggressive harvest strategy (Alternative 2) to a very restricted harvest strategy where fishing is only authorized with proof that no adverse impacts will occur (Alternative 4). Two intermediate policy alternatives are presented: Alternative 1, which would continue the current risk-averse policy, and Alternative 3, which would adopt a more precautionary policy. Each policy alternative contains a suite of policy goals and objectives, each addressing to various degrees the important components of the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA) marine ecosystems.

To help both the decision-maker and the public understand what a policy means and what environmental consequences may occur, we have defined example FMPs to illustrate each policy. These example FMPs contain a number of FMP components that were identified by the public as important features of any fishery management program. The best example of the current management policy are the current BSAI and GOA groundfish FMPs. For Alternatives 2 through 4, we define two example FMPs, each comprised of a different combination of management tools and tool applications. Each of these example FMPs contain concepts or specific suggestions obtained from NPFMC and the public. From an overall programmatic perspective, the actual characterization of the example FMPs and their effects is not as important as what is learned about the environmental trade-offs one can expect when considering alternative management policies governing the Alaska groundfish fisheries. Understanding these general environmental trade-offs will enable NPFMC, NOAA Fisheries, and the public to collectively shape future management policy and identify potential alterations to the existing management program.

The example FMPs also satisfy another purpose. NOAA Fisheries has determined that providing a management framework can help guide and communicate the direction of future actions. This is accomplished by including, as an element of the preferred alternative, two example FMPs that serve as "bookends" to a range of management actions, recognizing their inherent environmental consequences. Each example FMP will be analyzed separately and will proxy a range of future management actions. The bookend framework, comprised of two example FMPs, will indicate the range of environmental effects of that policy. The FMP bookends are not intended to be stand-alone alternatives. The FMP bookends are examples of management plans that are driven wholly by the policy statements. They illustrate different ways the groundfish fisheries can be managed and the range of environmental effects that can be expected from the implementation of a policy alternative. An FMP framework will be included in NPFMC's and NOAA Fisheries' final decision, and will be used to define a range of management actions that will be pursued following completion of the Programmatic SEIS. This alternative structure recognizes that the resource being managed, as well as the marine ecosystem, is quite dynamic in nature and only partially understood. Providing a range of management tools and their potential effects for each policy alternative is an attempt

to take into account the dynamic nature of the fisheries as a whole and to provide enough management program flexibility in each alternative to allow decisions based on the best available science.

Analyzing such a complex set of alternatives is difficult. Presenting our analysis in a single chapter of the Programmatic SEIS also has its challenges. This is first provided in Section 4.1, which describes the methods used to evaluate the alternatives and their associated FMP bookends. This section defines the term significance; describes how data gaps and incomplete information are treated; defines what is meant by direct, indirect, and cumulative effects; and provides a technical description of the multi-species model and its assumptions. Section 4.2 describes the concept of the FMP bookends and provides a detailed summary of each of the example FMP components used as proxies for a policy alternative. Section 4.3 provides the public with a qualitative examination of each FMP component and discusses the range of management measures that could later serve as plan amendments. In this qualitative assessment section, the public is provided with a general review of the likely environmental effects that could be expected from each of the measures, across example FMPs (Figure 4.0-1; illustrating the "row look"). Section 4.3 is intended to provide the public with information on what could be expected from each management tool (in relative isolation from other plan components), across a range of environmental effects categories, as well as an indication on how well these management tools may meet a particular set of policy objectives.

The Programmatic SEIS continues in Section 4.4 by reviewing the statements defining the current environmental baseline to which all the alternatives and their associated example FMPs will be compared. These baseline statements, developed in Chapter 3, provide an important reference point for this Programmatic SEIS. Sections 4.5 through 4.8 analyze Alternatives 1 through 4 by examining their associated example FMPs as proxies. Each FMP is analyzed as a whole (Figure 4.0-2; illustrating the "column look") so as to represent the entire FMP and all of its components. This is a marked departure from the 2001 Draft Programmatic SEIS document and is included as a result of considerable public input. Another difference between this and the 2001 Draft Programmatic SEIS is that this chapter is organized around alternatives, rather than by resource categories. Many members of the public recommended this organization as an improvement over the earlier draft.

Section 4.9 presents a policy analysis of each of the alternatives using the potential impacts of the example FMPs as a guide. Evaluation of each alternative is provided in terms of satisfying the Magnuson-Stevens Fishery Conservation and Management Act (MSA), Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA), and other applicable federal laws. Section 4.10 concludes this chapter by providing the public with an overall comparison of the alternatives at the policy level.

At this point, we feel obliged to beg the reader's continuing patience. The following analyses are unavoidably lengthy. We have tried to err on the side of inclusiveness, rather than run the risk of omitting any information or analysis that might aid decision-makers and the public in evaluating the relative merits of the alternatives. Also, the description of modeling methods in Section 4.1.5 contains highly technical information and mathematical equations that we have seen fit to include in the text rather than consign to an appendix. Although we do not expect that all readers will want to follow these equations variable by variable, we have placed the methods description prominently to allow public scrutiny of the scientific rigor with which the analyses have been conducted. Yet, however lengthy, detailed, and technical the analyses, we have tried our best where possible to keep the information accessible to the reader.

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4.1 Methodology

Alternatives are analyzed in the Programmatic SEIS to determine their environmental impacts. As previously described at the beginning of this chapter, each alternative is analyzed first at the FMP level, and later at the policy level. The FMP-level analysis examined both individual components as well as all of the components together, using the example FMPs, to determine the significance and intensity of impacts. A number of analytical models were used to conduct this analysis.

Section 4.1.1 discusses the significance thresholds used to analyze the impacts of the alternative, and Section 4.1.2 explains how data gaps and incomplete information were treated in this document. Section 4.1.3 describes the methodology for the direct and indirect effect analysis, and Section 4.1.4 describes methodology for the cumulative impact assessment. Section 4.1.5 describes the multi-species model, Section 4.1.6 describes the habitat model, and Section 4.1.7 describes the sector model used to estimate socioeconomic effects.

4.1.1 Determining Significance of Potential Consequences

The National Environmental Policy Act (NEPA) requires that an Environmental Impact Statement (EIS) include

> *... the environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented (40 Code of Federal Regulations [CFR] 1502.16).*

The EIS analysis must also identify whether or not an adverse environmental effect is significant. Significance is determined by considering the contexts (geographic, temporal, societal) in which the action will occur, and the intensity of the action. The evaluation of intensity should include consideration of the magnitude of the impact, the degree of certainty in the evaluation, the cumulative impact of the action as related to other actions, the degree of controversy over the action, and violations with other laws.

In this Programmatic SEIS, significance thresholds have been determined for each resource category (target species, socioeconomic effects, ecosystem, etc.). In some instances, although the significance threshold remains the same, the qualifier "conditional" is assigned. This indicates that a significant impact is assumed, based on credible scientific information and professional judgement, but that more complete information is needed for certainty. The following impact ratings may be used for each resource category:

Significantly adverse (S-): Significant adverse effect in relation to the reference point, based on ample information and data and the professional judgement of the analysts who addressed the topic.

Conditionally significant adverse (CS-): Conditionally significant adverse effect in relation to the reference point. This determination is lacking in quantitative data or information; however, the professional judgement of the analysts is that the alternative will cause a decline in the reference point condition.

Insignificant impact (I): Insignificant effect in relation to the reference point; this determination is based on information and data, along with the professional judgement of the analysts, that suggest that the effects will not cause a significant change to the reference point condition.

Conditionally significant beneficial (CS+): Conditionally significant beneficial effect in relation to the reference point. This determination is lacking in quantitative data and information; however, the professional judgement of the analysts is that the alternative will cause an improvement in the reference point condition.

Significantly beneficial (S+): Significant beneficial effect in relation to the reference point, based on ample information and data and the professional judgement of the analysts who addressed the topic.

Unknown (U): Unknown effect in relation to the reference point; this determination is characterized by the absence of information or data sufficient to adequately assess the significance of the impacts, either because the impact is impossible to predict, or because insufficient information is available to determine a reference point for the resource, species, or issue.

These ratings are applied to resource-specific impact indicators in the following resource categories: target species, prohibited species, other species, forage fish species, non-specified species, habitat, seabirds, marine mammals, socioeconomic effects, and ecosystem effects. The specific application for each is described below.

4.1.1.1 Target Species, Prohibited Species, Other Species, Forage Fish Species, Non-Specified Species

The significance of the impacts on target species, prohibited species, forage fish species, other species, and non-specified species was evaluated with respect to five effects: 1) fishing mortality, 2) change in biomass level, 3) spatial/temporal concentration of the catch, 4) prey availability, and 5) habitat suitability. The significance of these effects was evaluated as to whether the impacts, within the current fishery management regime, may be reasonably expected to jeopardize the sustainability of each target species or species group.

Target species are unique in that thresholds for overfishing and stock size have been developed (Amendment 56/56 to the BSAI and GOA FMPs) that relate to sustainability of the stock. As such, these thresholds are used to evaluate the significance of the effects of the example FMPs relative to their impacts on the sustainability of the target species. Fishing mortality rates that exceed the overfishing mortality rate are considered to jeopardize the capacity of the stock to produce maximum sustainable yield (MSY) on a continuing basis and adversely impact the sustainability of the stock. A related measure of this potential is indicated by change in biomass levels. The significance of effects of the current spatial/temporal concentration of the catch, and the level of prey availability and habitat suitability for target species is evaluated with respect to each stock's current size relative to its maximum stock size threshold (MSST). An action that jeopardizes the stock's ability to sustain itself at or above its MSST is considered to adversely affect the sustainability of the stock.

The significance of the five selected effects is evaluated according to the specific criteria for the impact ratings (Tables 4.1-1, 4.1-2, and 4.1-3). Species or species complexes that fall within Tiers 1 though 5 have estimates of the current fishing mortality rates and are evaluated with respect to exceeding the overfishing mortality rate (fishing mortality effect). Species or species complexes that fall within Tiers 1, 2, or 3 have

reliable estimates of MSST and are evaluated for the effects of spatial/temporal concentration of the catch, prey availability, and habitat suitability. Species or species complexes that fall within Tiers 4, 5, or 6 do not have reliable estimates of MSST and therefore cannot be evaluated for the significance of these effects. This inability to evaluate the significance of the effects also occurs for the forage, prohibited, and non-specified species. Since several species or species complexes do not have estimates of abundances-at-age, in this version of the model their abundance levels simply reflect the most recent estimate. For these groups, analysis of the effects of the example FMPs was limited to catch projections and likely consequences given patterns in related fauna.

4.1.1.2 Habitat

The potential effects of the groundfish fisheries on habitat that were used to compare the alternatives include mortality of, and damage to, living habitat, changes to benthic community diversity, and changes to the geographic diversity of impacts and protection. Specific impacts of groundfish fisheries on habitat are very difficult to predict. Evaluation of effects requires detailed information on the distribution and abundance of habitat types, the life history of living habitat, habitat recovery rates, and the natural disturbance regime. This information is generally incomplete.

Qualitative judgments as to the significance of effects were made after considering information on 1) bycatch of living habitat derived from the multi-species projection model; 2) the results of a habitat impacts model for estimates of the equilibrium levels of living habitat in fishable and currently fished areas; 3) estimates of the amount of area by habitat type and geographic zone closed year round to bottom trawling for all species; and 4) evaluation of the spatial distribution of bottom trawl closures relative to fishing intensity and habitat types. The evaluation criteria are described in Table 4.1-4. Significance determination in this analysis differs from the more commonly used approach in scientific research. Typically, the null hypothesis of no effect is tested rigorously and only rejected if there is a very low probability of it being true (Type I error). Scientists are trained to minimize the chance of a Type I error. In this Programmatic SEIS analysis, however, rigorous tests of available data to reject the hypothesis of no fishing effects were not relied upon to determine significance. This was done for two reasons. First, there was little information available to detect fishing effects, so rigorous statistical testing for a Type I error could not be performed. Second, it was believed that a more appropriate approach for this Programmatic SEIS was to decrease making a Type II error (accepting a hypothesis of no effect to habitat when an effect to habitat does actually exist. Reducing the probability of making a Type II error is more precautionary and is more responsive to both essential fish habitat (EFH) mandates and public comments received on the 2001 Draft Programmatic SEIS.

During the course of preparing the revised draft Alaska Groundfish Fisheries Programmatic SEIS, comments and questions were raised about the purpose and scope of the Programmatic SEIS and the agency's EFH EIS that is currently being prepared on a separate schedule. In response to these questions and to clarify the purpose and need, the following summary compares the two analyses.

<u>The Alaska Groundfish Programmatic SEIS and its Relationship to the Ongoing EFH EIS</u>

The EFH EIS and Groundfish Programmatic SEIS have different scopes and areas of focus.

EFH EIS. The analyses within the EFH EIS consider adverse effects of fishing on benthic marine habitat from the perspective of managed fish species that are dependent on certain qualities and features of that

habitat. As such, the scope of this work is more narrow than a consideration of these changes at the scale of entire marine ecosystems (as pursued in the Programmatic SEIS.)

Programmatic SEIS. The analyses within the Programmatic SEIS consider adverse effects of fishing on benthic marine habitat from the perspective of ecosystem structure and function, as well as managed fish species. As such, the scope of this work is broader than a consideration of these changes on commercially important and functionally dependent fish species.

These differences are reflected in the issues, criteria, and assessments made in each EIS. To a lesser extent, the information available for analysis in each EIS is different because the Draft Programmatic SEIS was written and released prior to the EFH EIS. The principal differences between the scope, alternatives, and purpose and need of the two documents are summarized in Table 4.1-1.

Table 4.1-1 Major differences between the Alaska Groundfish Fisheries Programmatic Supplemental Environmental Impact Statement and the Essential Fish Habitat Environmental Impact Statement.

	Programmatic Supplemental Environmental Impact Statement (SEIS)	Essential Fish Habitat (EFH) Environmental Impact Statement (EIS)
Purpose and need	Programmatic review of Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish Fishery Management Plans (FMPs) and their effects on the marine ecosystem.	Review of alternatives for identifying EFH, identifying habitat areas of particular concern (HAPCs), and minimizing adverse effects of fishing on EFH for groundfish, crabs, salmon, and scallops.
Action	Broad scope: Reauthorization of all groundfish fisheries under Magnuson-Stevens Act (MSA), Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), and other applicable law; set policy.	Narrower scope: Consider revising EFH designations and adopting mitigation measures to reduce the effects of fishing on EFH.
Alternatives	Broad multi-objective policies.	Alternative EFH designations, approaches to identifying HAPCs and mitigation measures.
Source of closed areas used in analysis	Based on public comments on 2001 draft Programmatic SEIS, EFH Committee (Fall 2002) concepts, internal analysis.	EFH Committee (finalized by North Pacific Fisheries Management Council in April 2003).
Legal authority	Under MSA, agency can take action to protect habitat even if not specified as EFH.	Under MSA, agency must minimize to the extent practicable adverse effects of fishing on EFH.

The different analyses used to assess the effects of fishing on habitat in the Programmatic SEIS and the EFH EIS are outlined in Table 4.1-2. While the Programmatic SEIS looks only at bottom trawl impact, the EFH EIS examines trawl, dredge, pot, and longline gear. Another difference is that the Programmatic SEIS usually cited results using the upper recovery value for soft bottom habitats (15 years, higher effects), while the EFH analysis uses a central value (5.5 years). However, both EISs acknowledge that impacts to benthic habitat

occur in areas of high fishing intensity regardless of the recovery rate assumed in the analysis. The same quantitative model relating fishing effort to habitat impact is used in both EISs and the results are highly comparable with only subtle differences, which have little effect on the ratings or discussion in the two EISs.

Table 4.1-2 Differences in data and methods for habitat effect analysis and evaluation issues.

	Programmatic supplemental Environmental Impact statement (SEIS)	Essential Fish Habitat (EFH) Environmental Impact Statement (EIS)
Input data source	Bottom trawl only.	Trawl, dredge, pot, longline.
Years	1997-2001.	1998-2002.
Fishery class	Trawl.	By target species and gear.
Living substrate recovery time (soft bottom)	2 and 15 years, 200 years for coral.	3.8, 5.5, and 10 years.
Habitat issues	Living habitat mortality/damage, including coral benthic community and geographic impact diversity.	Prey availability, epibenthic structure, coral.
Managed fish habitat issues	Habitat suitability.	Spawning/breeding, feeding, growth to maturity.

The Programmatic SEIS baseline evaluation identifies areas of high impact on living substrates and noted the estimated high potential impact level to living benthic structure and the size of affected areas. The analysis also considers the likelihood that those areas represent a unique habitat for managed fish species as determined by geography and oceanography, and is not equivalent to all other habitat in the same classification. The analysis concludes that, coupled with historical impacts, impacts to long-lived, slow-growing species (i.e., coral) could cause long-term damage and possibly irreversible loss of living habitat, especially in the Aleutian Islands. The baseline condition of benthic habitat is, therefore, rated as conditionally significant adverse. For purposes of making policy decisions, it is important that any potential significant adverse effects, even if conditional, be presented to decision-makers and the public so that consideration can be given to these effects when developing management measures in the future.

The EFH EIS describes the same areas of high impact to habitat features identified in the Programmatic SEIS, but goes on to evaluate the expected effects of such reductions in habitat quality on the welfare of each managed species. Those evaluations include areas occupied by each species, available information on their use of the habitat, and the stock history of each species. The Programmatic SEIS analysis evaluates impacts to the habitat itself, focusing on habitat features that might provide functions to managed species and speculating that linkages to productivity exist. Considering the paucity of information on habitat function for species life history stages and the broader scope of the Programmatic SEIS, the Programmatic SEIS does not depend on finding proof of such linkages. The EFH EIS examines the likelihood of significant linkages between habitat effects and the welfare of each managed species to determine whether the effects of fishing on EFH of managed species are more than minimal and not temporary. The purposes and methods of analysis used in the EFH EIS are discussed in more detail in Appendix B of the EFH EIS.

While the Programmatic SEIS baseline evaluation identifies areas of concern regarding of the current state of habitat effects from fishing, the EFH EIS was designed to specifically address criteria set forth in the EFH

final rule. While identifying areas of concern was one step in the EFH EIS, the ultimate purpose of the EFH EIS is to evaluate whether the effects of fishing has had negative effects on the EFH of managed species that was more than minimal and not temporary. Specific meaning of these terms are discussed in Appendix B of the EFH EIS.

The approach and methodology employed to assess the impacts on target groundfish species in the Programmatic SEIS and EFH EIS are similar. For each species in each EIS, a knowledgeable scientist was designated to perform an evaluation of whether the alternatives affected the welfare of each species in question relative to a number of key issues. In the Programmatic SEIS, the key issues are 1) fishing mortality; 2) change in biomass level; 3) spatial/temporal concentration of the catch; 4) prey availability; and 5) habitat suitability. The key issues analyzed in the EFH EIS are 1) stock biomass; 2) spatial/temporal concentration of the catch; 3) spawning/breeding; 4) feeding; and 5) growth to maturity. These issues are evaluated relative to the status quo fishery, or baseline condition, as well as to the alternatives developed under each EIS. Criteria are established for each issue to assist the analysts in making conclusions. The primary consideration in these evaluations revolve around the ability of the stock to maintain its health and support a sustainable fishery.

In the National Standard Guidelines to the MSA, sustainability is defined relative to a MSST, where stocks below the MSST are considered sufficiently small as to require an appropriate rate of rebuilding. This concept of sustainability is used in the Programmatic SEIS and EFH EIS to maintain consistency with the National Standard Guidelines. For Tier 3 fish stocks, estimated recruitments from the late 1970s to the present are used in defining MSST proxies. These estimated recruitments thus cover a range of recent history when impacts to the stock from fishing practices would be expected. Additionally, 10 year projections are made to assess whether the stock would be likely to fall below their MSST level under the status quo harvesting policy. In the EFH EIS, these projections are not available for the remaining mitigation alternatives. However, because each of the mitigation alternatives represents a more conservative harvest policy than the status quo alternative, a finding of stock status above the MSST under the status quo alternative could reasonably be expected to hold under the remaining alternatives.

It should be noted that the MSST criterion is not the only metric used for the evaluation. For some stocks, information is known about habitat associations and how these may be impacted under various harvesting regimes, from both previous studies and from the results of the Fujioka-Rose model. This information is presented in the narrative of the EFH EIS as part of the more focused look at the linkages between habitat impacts and sustainability. Additionally, for stocks in Tiers 4 through 6, MSST is not available, and an evaluation is based on professional judgment using the best available scientific information and evidence.

4.1.1.3 Seabirds

Significance criteria for seabirds are based on whether the proposed action would be likely to result in population level effects, defined as changes in the population trend outside the range of natural fluctuations. The projection model was used for predictions of fishing effort under the different FMP bookends, especially with respect to different gear types. The analysis also includes other factors such as spatial/temporal restrictions and potential gear modifications for seabird avoidance. However, because there are a large number of unpredictable variables and gaps in our knowledge about particular species and ecosystem effects, it is impossible to ascertain significance on a strictly quantitative basis. Conclusions are based on professional judgement of pertinent data and literature review.

Except for the supplemental food provided by the fisheries in the form of offal, the effects of the fisheries are all considered adverse to individual birds. Low levels of incidental take of seabirds are better for conservation purposes than high levels of take, but no amount of incidental take can be considered beneficial to a seabird population. The significance ratings for incidental take are, therefore, either insignificant or adverse. Although the number of seabirds that would be expected to be taken under the alternative FMPs varies considerably, this difference is not discernible by looking at a shared insignificant rating. The same type of situation applies to fishery-induced changes in benthic habitat important to benthic-feeding seabirds, so there is no beneficial rating for this effect. Effects of the fishery on food availability could be adverse, insignificant, or beneficial. If there is a plausible mechanism and a reasonable set of conditions under which an effect may occur under a given FMP, the significance rating may be labeled conditional. If there is a plausible mechanism for an effect, but not enough data to assess whether it occurs or whether the FMP would create the conditions under which it would occur, the significance rating may be unknown. The evaluation criteria are described in Table 4.1-5.

Species were grouped according to the similarity of their response to the groundfish fishery and/or similarity in their management status. Two species were analyzed on their own and the rest were discussed in five groups. The species categories and the main reason for their distinctions are listed below:

- Short-tailed albatross (listed as "endangered" under the ESA and have played a central role in the development of seabird protection measures).
- Laysan and black-footed albatross (do not breed in Alaska, conservation concerns regarding incidental take in fisheries).
- Shearwaters (do not breed in Alaska, most abundant seabird in Alaska in summer).
- Northern fulmars (the most frequently taken species in every groundfish gear type).
- Species of Management Concern (a U.S. Fish and Wildlife Service [USFWS] designation for species that may be susceptible to listing under the ESA, including red-legged kittiwakes, marbled murrelets, and Kittlitz's murrelets).
- Other piscivorous (fish-eating) species (most alcids, gulls, and cormorants).
- Other planktivorous species (storm-petrels and auklets).
- Spectacled and Steller's eiders (benthic feeding sea ducks listed as threatened under the ESA).

4.1.1.4 Marine Mammals

The standard for determining significance for effects on marine mammals is whether the impact would be expected to be detectable at the population level. Individual effects categories do not have to cause a measurable population decline or increase to be labeled significant, but data and/or plausible arguments must exist to determine that the action would have more than a negligible impact on the reproduction and/or survival of a species group in a way that could affect the population.

For each category of effects, it was determined wether the alternative fishing regime would result in significant adverse, insignificant, significant beneficial, or unknown effects on marine mammals. In addition, effects may be classified as conditionally significant, if significant effects could be expected under a plausible set of conditions. The intent of the conditional label is to imply uncertainty about whether an alternative FMP would actually result in conditions that led to a significant impact. When the conditional label is applied, a plausible mechanism for the impact and the conditions under which a significant impact would be realized is stated. In cases where data are lacking to rank an effect according to the significance criteria, the effect was determined to be unknown.

The expected effects of each alternative were compared to the baseline conditions to determine the relative significance of the impacts of the alternatives on marine mammals. The significant criteria are described in Table 4.1-6.

4.1.1.5 Socioeconomic Effects

In the socioeconomic impact analysis, the term significant for an expected change in a quantitative indicator means a 20 percent or more change (either plus or minus) relative to the comparative baseline. If the expected change is less than 20 percent, the change is not considered to be significant. The same threshold is roughly used to roughly assess changes in qualitative indicators (e.g., fishing vessel safety). However, whereas changes in quantitative indicators are based on model projections, predicted changes in qualitative indicators are based on the judgement of the socioeconomic analysts.

4.1.1.6 Ecosystem

Significance thresholds for determining the ecosystem-level impacts of fishing would involve both population-level thresholds that have already been established for species in the system (MSST for target species, fishing-induced population impacts sufficient to lead to listing under the ESA, and fishing-induced impacts that prevent recovery of a species already listed under ESA, for nontarget species) and community- or ecosystem-level attributes that are outside of the range of natural variability for the system (Table 4.1-7). These community or ecosystem-level attributes are more difficult to measure directly, and the range of natural variability of those attributes is not well known. We may also lack sufficient data on population status of target or non-target species to determine whether they are above or below MSST or ESA-related thresholds. Thus, indicators of the strength of fishing impacts on the system will also be used to evaluate the degree to which any of the alternatives may be having a significant ecosystem impact.

For each of the alternatives, the possible impacts on 1) predator/prey relationships, including introduction of non-native species; 2) energy flow and redirection (through fishing removals and return of discards to the sea); and 3) diversity will be addressed.

4.1.2 Data Gaps and Incomplete Information

The Council on Environmental Quality (CEQ) guidelines require that

> *When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an environmental impact statement and there is incomplete or*

unavailable information, the agency shall always make clear that such information is lacking (40 CFR 1502.22).

The regulations instruct that where the information is relevant, but "the overall costs of obtaining it are exorbitant or the means to obtain it are not known" (40 CFR 1502.22), the following should be included in the EIS:

- A statement that such information is unavailable.
- A statement of the relevance of the information to evaluate reasonably foreseeable significant adverse impacts.
- A summary of existing information that is relevant to evaluating the adverse impacts.
- The agency's evaluation of adverse impacts based on generally-accepted scientific methods.

In the analysis, this Programmatic SEIS identifies those areas where information is unavailable to support a thorough evaluation of the environmental consequences of the alternatives. Efforts have been made to obtain all relevant information; however, some data gaps still exist at this time due to several reasons, such as the costs of obtaining the missing data are exorbitant, the data will take several years to obtain, or the means to obtain the data are unknown. Limited resources to collect and analyze baseline information due to limited funding is problematic. NOAA Fisheries receives a certain level of funding, of which a certain amount is set aside for research on Alaska fisheries issues. The amount set aside for research (including data collection) is fully committed, and NOAA Fisheries cannot expend funds it does not have. Therefore, the cost of research needed to fill in current data gaps in addition to currently funded research is exorbitant. Examples of existing data gaps include the uncertainty of survey biomass estimates for many species, which in some cases would require the initiation of species-specific surveys to improve estimates; research needed to assess the use of existing and proposed refugia to improve reproductive success; and life history studies needed to elevate groundfish species in Tiers 4 through 6 into Tiers 1 through 3. NOAA Fisheries' Stock Assessment Improvement Initiative explicitly addresses these needs, and expanded stock assessment funds have been requested in NMFS proposed budgets. Where data gaps still exist, the Programmatic SEIS provided the information listed above, according to the CEQ guidelines.

As outlined in Section 4.1.1, the impact ratings used in this analysis include three categories that indicate a lack of complete data: unknown, conditionally significant adverse, and conditionally significant beneficial. In cases where these ratings are used, a discussion is included about the nature of the unavailable information and its relevance to this analysis. In cases where a conditional qualifier is used, the analysts, using credible scientific methods, have based their assessment on existing information and specific assumptions based on professional judgement in order to evaluate the reasonably foreseeable adverse or beneficial impacts. Where an unknown significance rating is used, not enough baseline information exists to evaluate the impact of the alternatives.

Section 5.1 catalogs the information that is unknown or unavailable for all resource categories. The section discusses ongoing and proposed research relating to the North Pacific groundfish fisheries, and lists the known data gaps for each resource category. Additionally, the specific research initiatives recommended in the various alternative policies are also identified.

4.1.3 Direct and Indirect Analysis

4.1.3.1 Target Species, Prohibited Species, Other Species, Forage Fish Species, Non-Specified Species

The impacts on target species, prohibited species, other species, forage fish species, and non-specified species were evaluated with respect to five effects: 1) fishing mortality; 2) change in biomass level; 3) spatial/temporal concentration of the catch; 4) prey availability; and 5) habitat suitability. Fishing mortality, biomass changes, and spatial/temporal concentration of the catch are considered direct effects, and prey availability and habitat suitability are considered indirect effects. The significance of these effects was evaluated according to whether they might be reasonably expected to jeopardize the sustainability of each species group within the current fishery management regime. Under FMP 1, all target species are managed within the definitions of Amendments 56/56 to the BSAI and GOA FMPs, which set the overfishing levels and the maximum permissible acceptable biological catch for six tier designations as described in Appendix B. Under FMP 1, only one stock is designated as falling within Tier 1 (eastern Bering Sea [EBS] pollock), and no stocks fall within Tier 2. Of the 21 BSAI target groundfish categories, 11 species are managed under Tier 3, no species are under Tier 4, eight species or species complexes are under Tier 5, and one species group (squid) is under Tier 6. Of the 16 GOA target groundfish categories, eight species are managed under Tier 3, seven species or species complexes are under either Tiers 4 or 5, and one species (Atka mackerel) is under Tier 6. The significance of the effects of the current fishing mortality levels is evaluated with respect to the overfishing mortality rates as set forth in Amendments 56/56.

As a means of evaluating the intensity (significance) of the effects on target species prohibited species, other species, forage fish species, and non-specified species under the alternatives, a system was developed whereby the significance of the five selected effects was evaluated. Additional details for each species or species complex are given in the specific section for that species or species complex. The system consists of four rankings of significance, including significant negative, unknown, insignificant, and significant positive. Recognizing that such general terminology is inherently subjective, we applied criteria where possible to define the terms and rankings. Where metrics were not available, descriptions of the impacts within the text are relied upon to justify the significance evaluation.

For the target species, the multi-species, multi-fisheries simulation projection model provided fundamental dynamics to the model behavior. That is, as the biomass of an FMP species changed in the future, the constraint (via acceptable biological catch/total allowable catch [ABC/TAC] control) also changed. The outputs from the model were primarily intended to reflect these dynamics and the interactions with the species composition of the different fisheries.

4.1.3.2 Habitat

This analysis focuses on the following question: do the alternative management policies result in conditions that offer protection to and minimization of adverse impacts to habitat? For Alaska groundfish, this includes the habitat for all target groundfish species, non-target species, prohibited species, other species, and their prey. When viewed in aggregate, across all species, habitat includes all pelagic and benthic habitat in the Alaska Exclusive Economic Zone (EEZ). However, the focus of this analysis is benthic habitat, which is generally believed to be at greater risk to the impacts of fishing than non-benthic habitat in the water column. In addition, much of the analysis focuses on the impacts of bottom trawling. It is recognized that fixed gear

(longlines, pots, and jigs) or pelagic trawl gear that comes in contact with the sea floor can disturb benthic habitat. In some types of habitat, fixed gear may cause an impact due to its ability to be more easily fished on rougher substrates (e.g., boulders with coral) than bottom trawl gear. However, most scientific studies of gear impacts have dealt with bottom trawls and dredging because this gear is the most controversial (Auster and Langton 1999, Jennings and Kaiser 1998, Hall 1999b, NRC 2002).

The impacts of bottom trawling on benthic habitat are described in Section 3.6.4. In general, relative to unfished habitat, areas fished with bottom trawls are expected to have reduced habitat complexity, reduced species diversity, and changes in species composition. The level of habitat complexity depends on the structural components of the living and non-living benthic environment. Habitat complexity is reduced when epifauna that form structures are removed or damaged, Sedimentary bedforms are smoothed, and infauna that form burrows and pits are removed. Worldwide studies of the effects of bottom trawling have generally found that trawling reduces habitat complexity (Auster and Langton 1999). These findings have been confirmed by studies conducted in Alaska (Freese *et al.* 1999, McConnaughey *et al.* 2000). The extent of the impacts depends on many factors, such as habitat type, natural disturbance, recovery rates, and the intensity and spatial distribution of bottom trawling.

Evaluating habitat impacts in marine fisheries is not a well developed field. There are few, if any, known applicable analytical methods for evaluating habitat. During the preparation of the Programmatic SEIS, we developed methods to evaluate impacts of fisheries on benthic habitat. Specific impacts on habitat, as noted above in Section 4.1.1.2, are difficult to predict, however, because the information needed to do so is generally incomplete for Alaskan waters. It may never be possible to fully and quantitatively account for all factors involved in determining how an ecosystem will respond to fishing activities. We have analyzed the direct and indirect effects identified in Table 4.1-4 by using, to varying degrees, four primary sources of information:

1. Estimates of the bycatch of living habitat derived from the multi-species projection model described in Section 4.1.5.

2. The results of a habitat impacts model (Fujioka 2002, Rose 2002) for estimates of the equilibrium levels of biostructure.

3. Estimates of the amount of area by habitat type and geographic zone closed year round to bottom trawling for all species.

4. Evaluation of the spatial distribution of bottom trawl closures relative to fishing intensity and habitat types.

We want to emphasize that while the multi-species model, habitat impacts model, and estimates of the amount of area by habitat type closed year round were used initially, these information sources later became peripheral to the habitat impacts analysis. The multi-species projection model was used by Programmatic SEIS analysts as a tool to determine impacts of the alternatives in future years. These data were obtained from the NMFS Observer Program. For the most part, we found that future projections of living habitat bycatch using these data and multi-species model results did not prove useful in analyzing habitat impacts as compared to target species and other fish species impacts. For example, the NMFS Observer Program aggregates all coral species into a single category. While these data are useful in documenting that these

benthic organisms are taken as bycatch in various groundfish fisheries, problems arise due to the wide variety of coral species and the vulnerability of hard versus soft corals to different gear types. Differences in recovery rates among species make assessing fishing impacts on these species difficult. All corals likely provide an important biostructure component to habitat for some of the managed species.

In order to run the habitat impact model described by Fujioka (2002; see Section 4.1.6) for the various alternatives, reliable catch and effort projections are needed. For example, for FMPs where the illustrated closure scheme differs substantially from the baseline in the location and amount of areal closures and/or fishing effort (example FMP 2.1, FMP 3.2 and FMP 4.1), the resolution of the data needed to run the model was not available.

Estimates of the amount of area by habitat type and geographic zone closed year round to bottom trawling for all species refers to some simple calculations of the amount of area closed to bottom trawling. While we present these data in the Programmatic SEIS for information purposes, this information was used sparingly to rate the alternatives in terms of habitat impacts.

As a result of these data limitations, our analysis relied most heavily on a comparison of maps of fishing intensity (presented by C. Rose [2002] at the Effects of Fishing Symposium) and closure area illustrations developed by the project team. This qualitative approach was an important part of the Programmatic SEIS analysis. Analysts would have liked to have conducted a more quantitative analysis of the spatial distribution of proposed closures relative to fishing intensity; however, there was only sufficient time to apply the data quantitatively to the status quo FMPs (e.g., FMP 1), and we used our best professional judgment in evaluating the other alternatives.

This analysis does not include impacts of trawling on non-living habitat, such as boulders, cobbles and sandwaves, which can be disturbed by bottom trawls (Auster and Langton 1999). In most cases, the structural integrity, and hence the complexity of the habitat, would not be greatly reduced, but when nonliving substrates are disturbed, the organisms living on them may die or be damaged.

Living Habitat – Direct Mortality of Benthic Organisms

Living habitat includes organisms that provide high microhabitat complexity and serves as cover for fish and their prey. Living habitats include: corals, sponges, anemones, sea whips, sea pens, and tunicates. Criteria to determine acceptable levels of mortality to living habitat have not been established. Such criteria would need to consider fishing induced mortality relative to such characteristics as natural mortality, fecundity, abundance, growth rates, and recruitment. Many deep water areas are characterized as stable environments dominated by long-lived species. In such areas, the impacts of fishing can be substantial and long-term (Auster and Langton 1999). Species such as red tree coral (Primnoa) are very long lived (more than 100 years old) and slow growing, and the habitat they provide does not easily recover if damaged by fishing (Risk *et al.*1998, Andrews *et al.* 1999, Krieger and Wing 2000). Recent studies indicate long recovery rates for deep water sponges that have been damaged or removed by trawling (Freese 2003). A potential quantifiable measure of the expected impact to such habitat are estimates of their living habitat bycatch derived from the multi-species projection model described in Section 4.1.5. Observer data from 1999 to 2001 provides information to estimate baseline levels of this bycatch (Tables 4.1-8 and 4.1-9). For the most part, we found that projections of bycatch of living habitat from the multi-species projection did not provide realistic data

to rate the alternatives. Thus, we relied more heavily on application of the habitat impacts model (see Section 4.1.6) as the tool to assess changes to direct mortality of benthic organisms.

There is also unobserved mortality and damage to living habitat that would not be reflected as bycatch (Freese *et al.* 1999, Krieger and Wing 2000, Freese 2003). Assuming that most living habitat caught as bycatch dies, then observed bycatch is a minimum estimate of fishing-induced mortality. We caution about comparing bycatch across gear types and fisheries. For example, if a particular fishery tends to catch more living habitat, this could indicate more impact for that fishery. However, there is little or no information to compare impacts between different gear types. Additionally, one gear type may be particularly efficient at catching and retaining an organism relative to the impact it has on living habitat, while another gear type may not retain the organism while causing a different level of impact. Such variability makes assessing fishing impacts very challenging and, as a result, this has been prioritized for research.

Benthic Community Diversity and Geographic Diversity of Impacts

Areas that are closed to fishing can protect living habitats from damage by fishing activities. In addition, closed areas can allow recovery of habitats already impacted by fishing. Ideally, placement of the closed areas would occur across a range of vulnerable, representative habitat types (National Research Council [NRC] 2002). Areas only seasonally closed to particular fisheries provide little protection to benthic habitat. For example, in the current BSAI and GOA FMPs, seasonal closures to Pacific cod, Atka mackerel, and pollock fishing exist in areas of sea lion foraging. These closures, however, provide little protection to benthic habitat because they are either fished seasonally and/or allow fisheries for other species. Thus, they address sea lion concerns, but fail to address the need to fully protect benthic habitat. Only year-round closures for all species are considered to provide protection to benthic habitat.

Simple calculations of the amount of area by habitat type and geographic zone closed to bottom trawling may provide some data to rate the alternatives. However these data do not provide information on the spatial distribution of closures relative to fishing intensity. Area calculations are mostly provided for information purposes.

Consideration must also be given to the geographic distribution of fishing intensity relative to closures. For instance, if closures are placed primarily in areas where there is little or no fishing then there will be little benefit to habitat over baseline levels. In contrast, if closures are placed primarily in fished areas that have high fish density and the displaced fishing effort moves to areas of low fish density, the result may be more habitat damage because greater effort may be required to catch the same amount of fish. Consideration of the geographic distribution of impact levels allows the habitat unit's distance and direction from other habitat, geographic, and oceanographic features to be accounted for.

We were able to apply the habitat impacts models to the status quo FMP (FMP 1) to quantitatively assess these direct effects. However, for the other alternatives we had to rely on a more qualitative approach. Thus, we used maps of baseline fishing intensity (Rose and Jorgenson 2002), and mapped alternative-specific closure areas to assess changes to benthic community diversity and geographic diversity of impacts.

Given that little is known about the habitat requirements of target, prey, or predator species in the BSAI and GOA and the location of specific habitats in these regions, managers must ask what is the best strategy for distributing fishing impacts over the potential fishing grounds? Should effort be distributed uniformly over

the fishing grounds, or should effort be concentrated in certain areas while leaving other areas unfished? If so, how large and in what orientation should the fished or unfished areas be? One may theorize that vast expanses of contiguous fishing effort or impact levels should be avoided. The evaluation of fishing impacts of example FMPs in this Programmatic SEIS operates under the following assertions and assumptions:

1. Knowledge about habitat value and its distribution is of low resolution based on gross bathymetric information, such as shelf, slope, gullies, or large scale geographic or oceanographic features, and we assume that such features capture benthic habitat.

2. Relative to habitat distribution, spatially diverse or patchy fishing impacts are preferable to uniformly distributed impacts (Duplisea *et al.* 2002). Thus, one of the criteria used to evaluate the alternatives will be the spatial and geographic diversity of fishing impacts. The patchiness of fishing effort may be enhanced by having some areas not fished dispersed within historically fished areas. This patchiness promotes habitat diversity.

3. Geographic diversity of impacts and protection is obtained by having a consistent pattern of varying levels of impact within a habitat type. This would be achieved most simply by establishing long-term closure areas over a portion of each habitat type within fished areas. Totally encompassing the habitat type or the cluster of historical fishing intensity within a closure, would not achieve a diverse impact.

4. Bathymetric features such as gullies, banks, shelf, slope, and slope/gully intersections represent individual general habitat types. In addition, clusters of fishing intensity represent an area of unique habitat, perhaps defined only in part by benthic habitat. In the GOA, the spatial resolution of these habitat types is on a much finer scale than the fairly uniform bathymetry of the Bering Sea. Habitat types in the Aleutian Islands are not as easily classified or distinguished, and are on an even finer spatial resolution.

4.1.3.3 Seabirds

Because of differences in foraging behavior, abundance, and distribution, some seabird species are more likely to be directly or indirectly affected by the groundfish fishery than others. Direct effects are those that take place at the same time and place as the fishing activity. Indirect effects are removed in time and/or space from the initial action. The mechanisms and history of direct and indirect effects of fisheries on seabirds are described in Section 3.7.1, along with other natural and human-caused influences on these effects. Details on the extent of each type of effect for each species, to the extent that they are known, are presented in the species accounts of Section 3.7.

For purposes of this chapter, some types of potential effects offer clearer comparisons of the alternatives than others. For seabirds, one direct effect (mortality) and two indirect effects (prey availability and benthic habitat) were analyzed to make the distinction between alternatives. Data on incidental seabird take come from the North Pacific Groundfish Observer Program and include birds that are killed or seriously injured in fishing gear or by striking the vessel or its rigging. Both indirect effects involve changes in the food supply of birds, but the mechanisms are different. Prey availability involves the removal of prey and competitors for that prey from the water column. Benthic habitat describes changes in the physical and biotic structure of the ocean bottom that potentially affect the capacity of that habitat to support the food web important to

seabirds. Consumption of fishery wastes has implications for both incidental take (attracting birds and resulting in increased vessel interactions) and food availability. Since incidental take is addressed in different ways by the different alternatives, and the production of fishery wastes is closely linked to overall TAC, consumption of fishery wastes will be incorporated into the analysis of effects on prey availability, which is related to fishing effort. The effects on benthic habitat are analyzed separately because they are more defined in space, and the alternatives vary considerably and specifically with fishing area closures.

Other potential effects, such as oil spills, plastic pollution, and introduction of nest predators, are the result of vessel traffic rather than fishing effort. An oil spill from a shipwrecked fishing vessel or the accidental release of rats from a ship to a seabird colony could have very substantial repercussions for one or more seabird species. However, the magnitude of the effect will depend on a host of variables that cannot be predicted. In addition, the risks of these types of events occurring are not necessarily proportional to fishing effort. Even the closure of the fishery would not eliminate these risks because the fishing and processing vessels would likely be used in other fisheries or brought to port where they may actually increase the risk of an effect (i.e., introduction of nest predators). Because these types of effects do not lend themselves to distinguishing between the alternatives, they will not be analyzed in the direct/indirect effects of each FMP. However, they are important to the overall effects of the fishery and are included as part of the baseline condition and as contributions to the cumulative effects.

Significance criteria were based on whether the proposed action would be likely to result in population-level effects, which are defined as changes in the population trend outside the range of natural fluctuations (see Section 4.1.1 for further details). The projection model was used for predictions of fishing effort under the different FMP bookends, especially with respect to different gear types. The analysis includes other factors such as spatial/temporal restrictions and potential gear modifications for seabird avoidance. However, because there are a large number of unpredictable variables and gaps in our knowledge about the natural history and populations of particular species, as well as many kinds of ecosystem effects, it was not possible to ascertain significance on a strictly quantitative basis. Conclusions are based on professional judgements of pertinent data, literature review, and the likelihood of certain conditions occurring.

4.1.3.4 Marine Mammals

Effects of the groundfish fishery management alternatives on marine mammals will be examined by focusing analyses around four core questions, which were modified from Lowry (1982):

- Is the alternative management regime consistent with efforts to avoid direct interactions with marine mammals (incidental take and entanglement in marine debris)?

- Does the alternative management regime result in harvests of fish species that are of particular importance to marine mammals as prey, at levels that could compromise foraging success (harvest of prey species)?

- Does the alternative management regime result in temporal or spatial concentration of fishing effort in areas used for foraging by marine mammals (spatial/temporal concentration of removals with some likelihood of localized depletion)?

- Does the alternative management regime modify marine mammal or forage behavior to the extent that population-level impacts could occur (disturbance)?

The existing environmental conditions under and independent of the 2002 fishery management measures were used as the baseline for comparing the alternatives with respect to effects on marine mammals, using the above questions to determine impacts. The expected effects of each alternative were compared to the effects as they exist under the baseline conditions to determine the relative significance of the impacts on marine mammals.

Direct Effect – Incidental Take/Entanglement in Marine Debris (Question 1)

Groundfish fisheries directly affect marine mammals when animals are incidentally caught or become entangled in fishing gear. When animals are incidentally taken or entangled, serious injury or mortality may or may not result. Some species are more susceptible than others to interactions with fishing gear, depending on the extent of spatial overlap with the fisheries and on the animals ability to detect and avoid gear. Fishery/marine mammal encounters that result in high levels of mortality and serious injury may have the potential to cause population-level effects. The level of incidental take and entanglement that results in population-level effects will vary according to the status and trajectory of each stock.

The MMPA requires that take of ESA- or MMPA-listed marine mammals incidental to commercial fisheries be authorized under a 101 (5)(E) permit upon determination that the incidental mortality and serious injury from these fisheries will have a negligible impact on the species or stock. For most activities, a negligible impact is defined as having a duration and intensity which results in an insignificant effect on the population. For fishing activities, the intensity of the effect is a more important consideration than the duration of the effect. If an impact is expected to cause no more than a ten percent delay in recovery of an ESA- or MMPA-listed species, then the impact is deemed negligible and will thus be insignificant. If incidental take and entanglement in fishing gear is expected to occur at a level which would delay recovery of a stock by more than ten percent than would be expected under baseline conditions, the impact will be significant. This approach allows for the incorporation of parameters specific to each population and thus accounts for the variable effects of incidental take according to the status and trajectory of each stock.

To calculate the delay in recovery imposed by additive mortality and injury incidental to fishing operations, definitions of the following are needed: the point at which the population is considered to be recovered, the current population size, and the intrinsic rate at which the population is increasing. For species with increasing population trajectories, it is possible to estimate the time until the population will be recovered. For species with negative population trajectories (declining stocks), the time period over which the population would be expected to go extinct can be estimated. If the additional mortality and serious injury resulting from incidental takes in commercial fisheries does not accelerate the estimated time to extinction by more than ten percent, the impact will be determined to be negligible at the population level, thus rendering it insignificant for purposes of this analysis.

Under the best-case scenario, incidental take and entanglement of marine mammals in fishing gear would be zero animal. Yet even under this scenario, the population effect on the species would be insignificant; therefore, effects ratings of (conditionally) significant beneficial are not applicable to this analysis.

Direct/Indirect Effect – Harvest of Key Prey Species (Question 2)

Direct and indirect interactions between marine mammals and groundfish fisheries occur due to overlap in the size and species of groundfish harvested in fisheries that are also important prey for marine mammals, and due to the spatial/temporal overlap in marine mammal foraging and commercial fishing activities. By design, fishing significantly reduces the spawning biomass of harvested species. The relevant question is whether fishing under these global (e.g., large-scale, such as BSAI- or GOA-wide) exploitation strategies reduces the environmental carrying capacity of marine mammals by affecting the prey on which they depend for survival.

Fishery removals of marine mammal prey may cause food availability to become the limiting factor regulating the size of the marine mammal population. If fisheries remove more of a prey species' standing biomass than is required to maintain a marine mammal population at the current size, the fishery would be deemed to have a significant adverse effect at the population level. Alternately, if a fishery management regime is expected to increase the available standing biomass of a prey species to a level such that the size and/or health of the marine mammal population is expected to increase, the fishery would be deemed to have a significant beneficial effect at the population level.

To make a determination of the point at which the alternate fishery regimes affect the availability of key prey species relative to the baseline to the extent that marine mammals experience population-level effects, it is necessary to know the following: the marine mammal's energy requirements; the relative contribution of each prey species to those energy requirements; the adequacy of the existing standing biomass of prey; the standing biomass of the prey species before and after the fishery; and how the change in the standing biomass equates to changes in the marine mammal population's vital rates or carrying capacity. With the best available scientific and commercial data, our current understanding of marine mammal bioenergetic requirements does not allow such a determination.

Due to the limited state of knowledge regarding the effects of the harvest of marine mammal prey species, we relaxed the requirement that varying levels of fishery removals be directly linked to effects which would be detectable at the population level. The significance criteria for this category of effects was selected to allow for informative comparisons of each fishery management alternative relative to the baseline. A 20 percent change in the fishing mortality rate relative to the baseline was selected as the significance threshold, as it was judged to result in large enough changes to the prey field such that significant impacts on marine mammal populations would reasonably be expected due to changes in the standing biomass of their key prey. Predicted fisheries harvest rates were modeled for each FMP scenario and FMP bookend using the Multi-species Analytical Model. Scenarios in which the fishing mortality rate (F) of key prey species is projected to increase by at least 20 percent were determined to have significant adverse effects on marine mammals, whereas a decrease in F of at least 20 percent was determined to have a significant beneficial effect. The effect of harvest of prey species was determined to be unknown when there was insufficient diet information for a given marine mammal species to determine if there would be overlap with the fisheries. After assessing the predicted change in fishing mortality rate of individual key prey species, a judgement was reached on the aggregate change in available standing biomass of marine mammal prey based on the factor discussed above, and whether this aggregate change from the baseline would have population-level effects on a species. This method of assessing the availability of prey is similar to the analysis used int the Steller Sea Lion Protective Measures EIS and the Steller Sea Lion BiOp. (NMFS 2001b and 2001c). In some cases the baseline

availability of prey is considered adverse for an individual marine mammal species; therefore lack of a change from the baseline would continue to be adverse.

Indirect Effect – Spatial/Temporal Concentration of the Fishery (Question 3)

Overall effects of fisheries on marine mammal populations vary according to the spatial/temporal concentration of the fishery. Although global fishery removals are designed to be precautionary, such that the productivity of target stocks and their ability to support natural predators are not compromised. In the times and locations where fisheries and marine mammals overlap, fisheries compete with marine mammals such that the resource can become limited. The intensity of the effects on marine mammals will vary according to the extent of competition (amount of overlap and degree of resource limitation) and the importance of the resource to marine mammals in a particular season or area. Because it is not possible to quantify the amount of competition between fisheries and marine mammals, nor to state the level of competition that results in changes at the population level, the effects of spatial/temporal fishing concentrations under the various alternatives were assessed qualitatively according to the spatial and seasonal foraging requirements of marine mammals. Alternatives were categorized as having significant adverse effects on marine mammal populations if there was much more spatial/temporal concentration in important foraging habitat and/or critical periods over baseline conditions (fishery conditions under 2002 rules and regulations). Significant beneficial effects were assigned if there was a much lower concentration of the fishery in key areas and seasons compared to baseline conditions. Unknown effects were assigned when there was insufficient information to determine what constitutes the key areas and seasons for a given marine mammal species.

Direct Effect – Disturbance (Question 4)

Activities related to groundfish fisheries in the BSAI and GOA have the potential to affect marine mammal behavior. Disturbance to marine mammals may result from vessel traffic, fishing operations, or underwater noise, such that otherwise normal behavior or movement patterns are altered. As defined here, these disturbances have significant adverse effects on marine mammal populations when marine mammal or forage behavior is modified to the extent that population level impacts could occur. Because it is not possible to quantify disturbance resulting from fisheries, nor to state the level of disturbance that results in changes at the population level, the level of disturbance expected to occur under the various alternatives was compared qualitatively to the baseline level of disturbance to evaluate the significance of the alternatives. The effects analysis for this category incorporated projections from the multi-species management model to determine changes in fishery patterns and information on marine mammal distributions and behavior to infer potential disturbance levels. The significance criterion was similar to that for evaluating fishery concentrations in time and space with substantially more disturbance from baseline conditions leading to a significant adverse finding. Insignificant effects were assigned for those species that do not appear to be disturbed by fishing vessels, and in cases where the level of disturbance was not expected to fluctuate to a large degree relative to the baseline. Under the best-case scenario, disturbance of marine mammals resulting from groundfish fishing activities would be zero. Even under this scenario, the population effect on the species would be insignificant; therefore, effects ratings of conditionally significant beneficial are not applicable to this analysis. Unknown effects were assigned when there was insufficient information to determine what constitutes disturbance for the species.

Marine Mammal Species and Species Groups

The effects of the alternative FMPs were analyzed on either individual species/stocks of marine mammals or on aggregate groupings of marine mammals according to the level and intensity of the expected effects or according to the status of the marine mammal stock. Species or stocks analyzed individually includes the western stock of Steller sea lions, the eastern stock of Steller sea lions, northern fur seals, harbor seals, transient killer whales, and sea otters. Marine mammals analyzed in aggregate include other pinnipeds, toothed whales (including resident killer whales), and baleen whales occurring in the BSAI and GOA groundfish fisheries. Western and eastern Steller sea lion stocks were split in the analysis due to the differences in their population trajectories, ESA listing status, and degree of overlap with groundfish fisheries. Northern fur seals and harbor seals were broken out from the other pinnipeds because they are expected to be more affected, directly or indirectly, by groundfish fisheries than the other pinniped species in the affected area. Transient killer whales were split out from the other toothed whales because their diets differ substantially from the other species in this category.

4.1.3.5 Socioeconomic Effects

Assessment of socioeconomic impacts considers the following important factors:

- Impacts on harvesting and processing sectors, including: catcher vessels, catcher processors, and inshore processors and motherships. Catches of all groundfish species, groundfish ex-vessel value and product value, groundfish employment and payments to labor, excess capacity, product quality, product utilization rates, average costs, and fishing vessel safety were used as variables.

- Regional impacts, on six regions (Alaska Peninsula and Aleutian Islands, Kodiak Island, Alaska southcentral, southeast Alaska, Oregon coast, and Washington inland waters), using processing, harvesting, payments to labor, and employment variables.

- Community Development Quota (CDQ)-related impacts, including changes to the CDQ program and changes to the CDQ species TACs.

- Impacts related to subsistence use of groundfish, Steller sea lions, and salmon, as well as opportunities for practicing subsistence.

- Environmental justice impacts resulting from changes in fishing activity, or impacts to the CDQ program or subsistence.

- Impacts on consumer benefits (U.S. consumers of groundfish products).

- Impacts on benefits from marine ecosystems (other than those benefits related to commercial groundfish fisheries), including non-market (existence value and option value, etc.), and other uses of the ecosystem, such as recreational fishing or tourism.

The socioeconomic impacts of the alternatives have been assessed using the Sector Model to estimate catch and processing amounts and revenues for the fishing and processing sectors and regions described in Section 3.9.2. The Sector Model uses output from the multi-species management model, combined with the

historical harvest and processing proportions, to estimate the distribution of catch and processing among the various sectors and regions that rely on the groundfish fishery.

The Sector Model is a three-step process that:

- Estimates total catch and deliveries to processors.
- Proportions out deliveries to specific catcher vessel sectors.
- Distributes catches and processing amounts among the various regions where processors are located or vessels are owned.

In each step of the Sector Model, the catch of each species by gear and subarea is distributed to successive sectors based on the historical distribution from 2001 (the baseline condition for socioeconomic effects). The model and analytical framework used in the analysis for the harvesting and processing sectors are described in Section 4.1.7.

4.1.3.6 Ecosystem

Ecosystems consist of populations and communities of interacting organisms and their physical environment that form a functional unit with a characteristic trophic structure and material cycle (i.e., how energy or mass moves within the unit). Fishing has the potential to influence ecosystems in several ways. Fishing may alter the amount and flow of energy in an ecosystem by removing energy and altering energetic pathways through the return of discards and fish processing offal back into the sea and through mortality of organisms not retained in the gear. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system. Selective removal of species and/or sizes of organisms that are important in marine food web dynamics such as nodal prey species or top predators has the potential to change predator/prey relationships and community structure. Removals concentrated in space and time may impair the foraging success of animals tied to land such as pinnipeds or nesting seabirds; these animals may have restricted foraging areas or critical foraging times that are key to survival or reproductive success. Introduction of non-native species may occur through emptying of ballast water or introduction of hull-fouling organisms from ships from other regions (Carlton 1996). Introductions of such species have the potential to cause large changes in community dynamics. Fishing can alter different measures of diversity. Species-level diversity, or the number of species, can be altered if fishing essentially removes a target or nontarget species from the system. Fishing can alter functional diversity if it selectively removes a trophic or other ecosystem member and changes the biomass distribution among a trophic groups. Fishing gear may alter bottom habitat and damage benthic organisms and communities that serve important functional roles as structural habitat or within the food web. Fishing can alter genetic-level diversity by selectively removing faster growing fish or removing spawning aggregations that might have different genetic characteristics than other spawning aggregations.

A great deal of literature addresses possible indicators of ecosystem status in response to perturbations (e.g., Odum 1985, Pauly *et al.* 1998, Rice and Gislason 1996, Murawski 2000). These indices can show changes in energy cycling and community structure that might occur due to some external stress such as climate or fishing. For example, fisheries might selectively remove older, more predatory individuals. Therefore, we would expect to see changes in the size spectrum (the proportion of animals of various size groups in the

system), mean age, or proportion of r-strategists (faster growing, more fecund species, such as pollock) in the system. These changes can increase nutrient turnover rates because of the shift towards younger, smaller organisms with higher turnover rates. Total fishing removals and discards also provide a measure of the loss and re-direction of energy in the system due to human influences. Total fishing removals relative to total ecosystem energy could indicate the importance of fishing removals as a source of energy removal in an ecosystem. Changes in scavenger populations that show the same direction of change as discards could be an indicator of the degree of influence discards have on the system. Discards as a proportion of total natural detritus would also be a measure that could indicate how large discards are relative to other natural fluxes of dead organic material. Levels of total fishing removal or fishing effort could indicate the potential for introduction of non-native species through ballast water in fishing vessels. Fishing practices can selectively remove predators or prey; tracking the change in trophic level of the catch may provide information about the extent to which this is occurring (e.g., Pauly *et al.* 1998). Thus, in this analysis, we use measures of total catch, total discard, and information about the changing mean size of organisms to indicate the potential of each of the alternatives to impact ecosystem energy flow and turnover.

Total catch and trophic level of the catch will provide information about the potential to disrupt predator/prey relationships through introduction of non-native species or altering the food web through selective removal of predators, respectively. Pelagic forage availability will be measured quantitatively by looking at population trends of pollock and Atka mackerel, target species that are key forage for many other fish and marine mammal species in the BSAI and GOA. Bycatch trends of nontarget species, such as the managed forage species group and herring, will be used as indicators of possible fishery impacts on those pelagic forage groups. Angermeier and Karr (1994) recognized that an important factor affecting the trophic base is spatial distribution of the food. The potential for fishing to disrupt this spatial distribution of food, which may be particularly important to predators tied to land, will be evaluated qualitatively to determine the degree of spatial/temporal concentration of fishery removals of forage. We will evaluate these factors to determine the potential of each of the alternatives to disrupt predator/prey relationships.

The scientific literature on diversity is somewhat mixed about what changes might be expected due to a stressor. Odum (1985) thought that species diversity (number of species) would decrease and dominance (the degree to which a particular species dominates the system in terms of numbers or biomass) would increase, if original diversity was high. The reverse might occur, if original diversity was low. Significance thresholds for species-level diversity due to fishing are catch removals high enough to cause the population of one or more target or non-target species to fall below minimum biologically acceptable limits. The MSST for target species, would either trigger ESA listing or would prevent recovery of an ESA-listed species. Genetic diversity can be altered by humans through selective fishing (removal of faster growing individuals or certain spawning aggregations). Accidental releases of cultured fish and ocean ranching tends to reduce genetic diversity (Boehlert 1996). Significance thresholds for genetic diversity impacts due to fishing would be catch removals high enough to cause a change in one or more genetic components of a target or non-target stock that would cause it to fall below minimum biologically acceptable limits (e.g., MSST for target species, ESA listing or non-recovery of ESA-listed species). More recently, there is growing agreement that functional (trophic or structural habitat) diversity might be the key attribute for ecosystem stability (Hanski 1997). This type of diversity ensures there are a sufficient number of species that perform the same function. If one species declines for any reason (human or climate-induced), then alternate species can maintain that particular ecosystem function, and there we would be less variability in ecosystem processes. However, measures of diversity are subject to bias, and we do not know how much change in diversity is acceptable (Murawski 2000). Furthermore, diversity may not be a sensitive indicator of fishing effects (Livingston *et*

al. 1999, Jennings and Reynolds 2000). Nonetheless, we will evaluate the possible impacts that the alternatives may have on various diversity measures.

Quantitative measures of some of the indicators mentioned above have been identified for each of the alternatives. These include total catch, trophic level of the catch, total discards, total groundfish biomass, trophic level of groundfish biomass, bycatch amount of forage, top predator species, and habitat area of particular concern (HAPC) biota for the BSAI and GOA. We will address for each of the alternatives the possible impacts on predator/prey relationships, including introduction of non-native species; energy flow and redirection (through fishing removals and return of discards to the sea); and diversity.

4.1.4 Cumulative Effects Methodology

4.1.4.1 Introduction

Analysis of the potential cumulative effects of a proposed action and its alternatives is a requirement of NEPA. An EIS must consider cumulative effects when determining whether an action significantly affects environmental quality. The CEQ guidelines for evaluating cumulative effects state that "…the most devastating environmental effects may result not from the direct effects of a particular action but from the combination of individually minor effects of multiple actions over time" (CEQ 1997).

The CEQ regulations for implementing NEPA define cumulative effects as

> *the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7).*

Cumulative effects are linked to incremental actions or policy changes that individually may have small outcomes, but that in the aggregate and in combination with other factors can result in greater effects in the BSAI and GOA. At the same time, the CEQ guidelines recognize that it is not practical to analyze the cumulative effects of an action on the universe, but to focus on those effects that are truly meaningful.

The cumulative effects analysis assesses the potential direct and indirect effects of groundfish FMP policy alternatives in combination with other factors that affect physical, biological, and socioeconomic resource components of the BSAI and GOA environment. Peer reviewed literature and quantitative research on the cumulative effects of fishing activities in the Bering Sea and GOA are limited. The cumulative effects analysis presented for each of the FMP policy alternatives addresses the potential magnitude of effects and is somewhat qualitative in nature.

The intent of the cumulative effects analysis is to capture the total effects of many actions over time that would be missed by evaluating each action individually. A cumulative effects assessment describes the additive and synergistic result of the actions proposed in this Programmatic SEIS as they interact with factors external to those proposed actions. To avoid the piecemeal assessment of environmental impacts, analysis of cumulative effects were included in the 1978 CEQ regulations, which led to the development of the CEQs cumulative effects handbook (CEQ 1997) and federal agency guidelines based on that handbook (e.g.,

USEPA 1999). Although predictions of direct effects of individual proposed actions tend to be more certain, cumulative effects may have more important consequences over the long-term. The possibility of these hidden consequences presents a risk to decision-makers, because the ultimate ramifications of an individual decision might not be obvious. The goal of identifying potential cumulative effects is to provide for informed decisions that consider the total effects (direct, indirect, and cumulative) of alternative management actions. This section characterizes the incremental cumulative effects that potentially arise from external factors in combination with the direct and indirect effects.

4.1.4.2 Methodology

The methodology for cumulative effects analysis in this Programmatic SEIS consists of the following steps:

- *Identify characteristics and trends within the affected environment that are relevant to assessing cumulative effects of the FMP policy alternatives, including lingering effects and how they have contributed to the comparative baseline.* This information is presented in Chapter 3 of this Programmatic SEIS and summarized in the cumulative effects sections for each of the alternatives.

- *Describe the potential direct and indirect effects of èach of the four FMP policy alternatives.* This information is presented in detail in Sections 4.5 through 4.9 of this Programmatic SEIS, and is summarized in the cumulative effects ranking tables. The cumulative effects analysis uses the specific direct and indirect effects that have been evaluated for comparison with external factors.

- *Identify past, present, and reasonably foreseeable external factors such as other fisheries, other types of human activities, and natural phenomena that could have additive or synergistic effects.* Past actions must be evaluated to determine whether there are lingering effects that may still result in synergistic or incremental impacts when combined with the proposed action alternatives. The CEQ guidelines require that cumulative effects analysis assess reasonably foreseeable future actions. Because analysis of relevant past, present, and future effects depends on the resource or characteristic being evaluated, the time period for looking at past and reasonably future effects will vary. Both past BSAI and GOA FMP amendments and pertinent external factors used to evaluate potential effects are described further in this introduction.

- *Use cumulative effects tables to screen all of the direct/indirect effects with external factors to capture those synergistic and incremental effects that are potentially cumulative in nature.* Both adverse and beneficial effects of external factors on the criteria used for direct and indirect effects are assessed, and then evaluated in combination with the direct and indirect effects to determine if there are cumulative effects.

- *Evaluate the significance of the potential cumulative effects using criteria established for direct and indirect effects and the relative contribution of the action alternatives to cumulative effects.* Of particular concern are situations where insignificant direct and indirect effects lead to significant cumulative effects or where significant external effects accentuate significant direct and indirect effects.

- *Discuss the reasoning that led to the evaluation of significance, citing evidence from the peer-reviewed literature and quantitative information where available.* As with direct and indirect

effects, the term conditional significance has been used where conclusions of significance have been based on reasoned assumptions, and the term unknown is used where there is not enough information to reach a conclusion of significance.

The advantages of this approach are that it closely follows CEQ guidance, employs an orderly and explicit procedure, and provides the reader with the information necessary to make an informed and independent judgment concerning the validity of the conclusions.

The CEQ (1997) has established step-by-step guidelines for conducting a cumulative effects analysis. The guidelines set forth 11 steps that can be classified into four basic stages: scoping, organizing, screening, and evaluating. Table 4.1-10 shows how the cumulative effects assessment for groundfish fisheries management was adapted to closely follow the CEQ guidelines.

4.1.4.3 Scoping

A historical review of the BSAI and GOA FMP amendments was conducted, looking at the intent and consequences of FMP amendments since 1980. This information was used to prepare the comparative baseline that is presented in Chapter 3 and summarized in Section 4.4. In addition to issues that were derived from the historical FMP amendment review, both the scoping process and public review of the first draft of the Programmatic SEIS identified issues to be addressed in the cumulative effects analysis. The scoping comments identified two major issues associated with analysis of potential cumulative effects: the consideration of the additive effects of management actions over time and the cumulative effects of the management regime as a whole, and the consideration of impacts of natural events versus fisheries management on the ecosystem, including the human component (socioeconomic and subsistence) of fishing communities.

Public comments on the first draft of the Programmatic SEIS identified 15 themes associated with the scope and conclusions of the analysis of potential cumulative effects. Among the suggestions was that the cumulative effects analysis use a different baseline to compare the alternatives than the status quo management system. A summary of these issues can be found in the Scoping Summary Report (NMFS 2000a) and Comment Analysis Report (Appendix G).

4.1.4.4 Additive and Cumulative Effects of Past FMP Amendments

The potential effects of the original BSAI and GOA FMPs and their amendments are difficult to substantiate quantitatively. Given the inherently large fluctuations that occur naturally in fish populations and the complexity of the North Pacific fishery, it is not feasible to identify biological responses to managerial decisions designed to fine tune fishery harvests under the mandate of both preserving stocks and maximizing commercial exploitation. Intended and unintended socioeconomic effects on the fishing industries and regions and communities that participate in the groundfish fishery are easier to assess. The analysis of FMP amendments was used to develop the comparative baseline presented in Chapter 3 and summarized in Section 4.4, and to identify lingering effects to carry forward into the cumulative effects analyses in Sections 4.5 through 4.9.

4.1.4.5 Identification of External Factors and Effects

A cumulative effects analysis takes into account the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions (40 CFR 1508.7). External factors play an important role in developing the comparative baseline used to evaluate the effects of the proposed action and its alternatives, and to identify present and reasonably foreseeable future actions that are relevant to the cumulative effects analysis. For the purposes of this Programmatic SEIS, the definition of external actions includes both human controlled events such as other fisheries, pollution, and industrial development, and natural events such as disease, winter mortality, and short-and long-term climate change.

In order to ascertain the importance of the external impacts in the cumulative effects analysis, a comprehensive checklist was produced for each resource category (marine mammals, seabirds, target species, non-target species, prohibited catch species, habitat, socioeconomic characteristics, and ecosystem). Information presented in the checklists was obtained from reviewing EISs, reports and resource studies, and peer-reviewed literature. The identified external factors were discussed in meetings with staff of the NOAA Fisheries Alaska Fisheries Science Center (AFSC) to confirm accuracy, identify any effects that might have been missed, and explore pathways through which the external influences might act in an additive or interactive fashion with the alternatives to produce cumulative effects.

Within each resource checklist the effects were divided into the two main categories: human controlled events, and natural events. Due to inherent differences between socioeconomic resources and biological resources and systems, external effects impacting the socioeconomic category were developed to consider different events and topics, or different aspects of the same event. For example, potential biological factors of other fisheries include disturbance and habitat damage, whereas potential socioeconomic factors include the contribution of participation in other fisheries to the overall viability of fishing industry harvesters and processors. Table 4.1-11 summarizes the external effects that have been incorporated into the cumulative effects analysis.

4.1.4.6 Organizing the Cumulative Effects Analysis

Potential cumulative effects of each of the policy alternative FMPs are presented in Sections 4.5 through 4.9. For each of the alternatives, the analysis of cumulative effects follows the analysis of direct and indirect effects within the discussion of each of the major resource topics (e.g., Target Fish, Marine Mammals, Socioeconomic Characteristics). The structure of the cumulative effects analysis also parallels the direct and indirect effect analysis in the organization of the impact screening tables. The categories of effects evaluated for each of the direct/indirect analyses are used to organize the cumulative effects screening tables.

The categories of effects to be evaluated were developed jointly by analysts preparing the direct/indirect and cumulative effects analyses. These effects appear in the far left hand column of both the direct/indirect and cumulative effects matrices. This approach facilitates evaluating the additive and synergistic effects of the FMP policy alternatives with past FMP amendments and external effects. It also provides transparent logic for those reviewing the Programmatic SEIS.

4.1.4.7 Screening Potential Cumulative Effects

The screening process for the cumulative effects analyses consists of the following steps:

- Identify the cause and effect relationships and incorporate them into the categories of effects to be evaluated for the direct/indirect and cumulative effects analyses.

- Identify whether potential effects on a given resource from past external actions remain, and whether they have a lingering effect on the resource that contributes to the significance of potential cumulative effects.

- Identify potential effects on a given resource from both direct and indirect effects of the policy alternative FMPs and from present and reasonably foreseeable external actions.

- Develop and utilize matrices as the organizational structure to incorporate past effects, direct/indirect effects, and the potential effects of present and reasonably foreseeable events in evaluating the potential for and significance of cumulative effects.

As indicated above, parallel impact assessment tables or matrices have been constructed to screen and evaluate direct, indirect, and cumulative effects, and to ensure that the evaluation is orderly and systematic. Each direct and indirect matrix scores the alternatives with respect to the impacts they could produce on the subject resource component. The range of scores includes insignificant, significant, conditionally significant, and unknown. A plus (+) or minus (-) is added to the significant or conditionally significant score to indicate a beneficial or adverse effect, respectively.

A second series of matrices was prepared for each resource component under each alternative. The cumulative effects matrices tabulate the external factors identified in the scoping process (columns) against the direct and indirect effects that have been identified. Under a single resource category (e.g., marine mammals), a separate cumulative effects matrix was prepared for each resource component (e.g., Steller sea lion, northern fur seal, harbor seal, etc.). The matrices include both beneficial and adverse environmental effects associated with past, present, and potential future management decisions related to the four policy alternatives. External effects that could function additively or interactively with the direct and indirect effects of the alternatives are organized into two major categories of human controlled and natural events.

4.1.4.8 Evaluating the Significance of Potential Cumulative Effects

The potential for cumulative effects and their significance was evaluated for the resources and characteristics of the human environment described in Chapters and 3 and 4. For biological, habitat, and ecosystem resources and characteristics, significance criteria and thresholds take into account the geographic scope, population level implications, and regulatory aspects of potential effects. Significance criteria and thresholds for socioeconomic characteristics take into account the relative magnitude of change, the geographic distribution of effects, and the regulatory aspects of potential effects.

Table 4.1-12 is an example matrix illustrating the approach taken to evaluate cumulative effects. Starting in the far left-hand column, the category of effect used in both the direct, indirect, and cumulative effects analysis is presented, along with a significance rating for the direct and indirect effect. Any persistent past effects to be carried forward in the cumulative effects analysis are identified. Next, reasonably foreseeable future human controlled and natural effects are identified and briefly described, along with the nature of contribution to cumulative effects. Categories include potential adverse or beneficial contribution, not a contributing factor, and unknown. The direct and indirect, persistent past, and external effects are then

integrated to determine whether there is a cumulative effect and its significance. The far right hand column summarizes the cumulative effect and whether it is significant, conditional significant, insignificant, or unknown. Several rules of logic are applied to the process. If the direct/indirect effect is unknown, it is not possible to determine the cumulative effect, which is also unknown. If there are no persistent past effects and there are no reasonably foreseeable future effects (not a contributing factor), then there are no cumulative effects for a specific effects category. The logic for applying ratings of conditional significance and unknown is the same for direct and indirect effects (see Sections 4.1.2 and 4.1.3). The cumulative matrix tables are supported by text that describes in more detail the persistent past effects, relevant external factors, and the logic in determining the significance of cumulative effects.

4.1.5 Description of the Multi-Species Analytical Model and its Assumptions

4.1.5.1 Background

In the Draft 2001 Programmatic SEIS, simulation models were developed that evaluated individual stocks independently, as if each species could be caught separately from other species. The simulation model thus failed to reflect the multi-species character of nearly all Alaska groundfish fisheries, which catch a wide variety of species even when targeting a single species. This meant that in many cases, single-species simulations did a poor job of representing the likely consequences of alternative management scenarios. For this revised Programmatic SEIS, simulation models have been developed that reflect the multi-species nature of the fisheries and their management.

Current groundfish management in federal waters of Alaska consists of strict quota management for FMP-managed species. These quotas are closely monitored, and as quotas are approached in a given year, with reserves set aside for bycatch in other fisheries, directed fisheries become closed. Prohibited species catch (PSCs) limits are also closely monitored and affect fishing season length and area openings. These quotas and PSCs effectively become constraints for all groundfish fisheries operating in the GOA and BSAI regions. These constraints are established based on area-specific TACs. The TACs are derived from the NPFMC's annual recommendations for ABC levels. As a matter of policy, the NPFMC's TAC for a given species or species group has always been less than or equal to the ABC for that species. The resulting management system is one that strives to meet the objective of providing fishing opportunities subject to a large number of constraints. Analysis of this type of fisheries regime has been modeled using Linear Programming (e.g., Brown *et al.* 1979, Siegel *et al.* 1979, and Murawski and Finn 1986). In this Programmatic SEIS, we attempt to mimic management of complex interacting fisheries and their impact on GOA and BSAI living marine resources using a similar approach.

Simulating current groundfish management in the U.S. North Pacific economic zone involves considering interactions between a large number of species, areas, and gear types. These fisheries are managed subject to a large number of constraints (e.g., ABCs and PSCs). Management decisions are based on expectations about the array of species likely to be captured by different gear types and the cumulative effect that each individual fishery has on the allowable catch of each individual species or species group. The expectations of capture by different fisheries are based on historical catch data of each species within area and gear strata. The ABC constraints come from probabilistic projections of future stock dynamics for each individual species. Given these constraints, the predicted catch for each example FMP is then computed from an inseason management model. This management model accounts for the technical multi-species interactions of the groundfish fisheries (see Ackley 1995 for an example application of within-year patterns for the EBS

fishery). Finally, the predicted catches are fed back into the age-structured information for each species to compute the correct fishing mortality level and are then projected through each year. This provides a reasonable representation of the current fisheries management practice for dealing with the multi-species nature of bycatch in target fisheries. Fisheries are defined by distinct target species, gear type, and area. The optimal decision-making process related to actual removals is simulated using historical information on catch composition of these fisheries. A schematic of the modeling approach is presented in Figure 4.1-1.

This section begins with a description on how individual stocks are treated and projected into the future, including details on how the constrained optimization is used to mimic management. A critique of the approach and assumptions follow. The subsequent section describes how catch estimates were derived, followed by how specific alternatives were modeled (including the data that were used). This section then concludes with a brief description on how model results were applied in different resource categories (e.g., to assess the impact on marine mammals).

4.1.5.2 Methods

Treatment of Stocks

For the stocks with age-structure information, the model is very similar to those used for the stock assessments upon which ABC recommendations are currently based, and it contains features and assumptions common to many fishery population dynamics models. Parameters and other inputs were obtained for each stock. They were taken directly or inferred from the most recent Stock Assessment and Fishery Evaluation (SAFE) report or obtained from AFSC scientists. The simulations began with numbers of a given age in 2002, which were projected forward using a random recruitment simulator (Inverse Gaussian) and a fishing mortality rate defined by the FMP under consideration. Recruitments were drawn from a statistical distribution that is described below. The parameters consisted of maximum likelihood estimates obtained from the recruitments listed in the 2002 SAFE report. Recruitment estimates after 1978 were used to estimate distribution parameters. No serial correlation was assumed. The age of recruitment varied between stocks, corresponding to the minimum age used in the respective assessment models. For stocks where age-structure information is not available, but ABCs are set, the model used the most recent estimates of ABC as the upper limit on total catch. The list of species considered for the BSAI and GOA is presented in Table 4.1-13. The actual age-structure data used for the analyses are available online at www.fakr.noaa.gov/sustainablefisheries/seis/data.

Projection Model

The following presents details on the steps of the projection simulations. A glossary of notation is provided at the end of this section for reference.

Step 1: Select the Catch Composition Array Appropriate for the Alternative

As presented below, separate hypothetical catch-composition arrays were developed for each alternative. A catch-composition array can be simply thought of as a table where the rows represent a specific fishery defined by target species, area, and gear type, and the columns represent the catch by species group or stock (See www.fakr.noaa.gov/sustainablefisheries/seis/data).

Step 2: Project Recruitments for all Years and Simulations

Recruitment estimates for the years 1978 through 2001, or the largest available subset thereof, were obtained from each of the respective 2002 stock assessments. For each stock, these recruitments were used to find maximum likelihood estimates for the inverse Gaussian distribution parameters. The distribution was parameterized such that one of the parameters represented the distribution mean. A recruitment time series was obtained for each simulation by drawing randomly from this parametric distribution.

Step 3: Estimate Actual Fishing Mortality Rates for the Initial Year

The steps in this part of the model are described below. Because the example FMPs were assumed not to take effect until after 2002, these steps were conducted only once, rather than separately for all eight FMPs. Compute the fishing mortality rate that would set catch equal to C_t by solving the following implicit equation:

$$C_{2002} = F_{2002}\sum_{a=1}^{n_{age}}\left[N_{a,2002}\left(\frac{1-\exp\left(-M_a - F_t\sum_{k=1}^{n_{year}} s_{a,k}d_k\right)}{M_a + F_t\sum_{k=1}^{n_{year}} s_{a,k}d_k}\right)\sum_{k=1}^{n_{year}} w_{a,k}s_{a,k}d_k\right]$$

Step 4: Project Numbers at Age for all Ages, Years, and Simulations

For each example FMP, 200 projection simulations were conducted. The projected numbers at age in each year were based on an annual feedback of actual catch obtained from the linear programming constrained optimization algorithm, hereafter referred to as the LP. The steps for these projections for a given species were as follows:

1. Initialize the simulation index:

   $u = 0$

2. Increment the simulation index:

   $u = u + 1$

3. Initialize the time index:

   $t = 1$

4. Compute numbers at age for initial year of simulation u:

   $N_{a,t,u} = R_{t,u}$ for $a = 1, t = 1$

   $N_{a,t,u} = n_a$ for $a > 1$

5. Set fishing mortality rate for initial year of simulation u:

   $F_{t,u} = F_{2002}$

6. Increment time index:

   $t = t + 1$

7. Compute numbers at age in year t of simulation *u*:

$$N_{a,t,u} = R_{t,u}, \qquad R_{t,u} \sim \text{InvGaussian}(\beta, \gamma) \qquad \text{for } a=1$$

$$N_{a,t,u} = N_{a,t-1,u} \exp\left(-M_a - F_{t-1,u} \sum_{k=1}^{n_{year}} s_{a,k} d_k \right) \qquad \text{for } 1< a < n_{age}$$

$$N_{a,t,u} = N_{a,t-1,u} \exp\left(-M_a - F_{t-1,u} \sum_{k=1}^{n_{year}} s_{a,k} d_k \right) + \qquad \text{for } a = n_{age},$$
$$N_{a-1,t-1,u} \exp\left(-M_{a-1} - F_{t-1,u} \sum_{k=1}^{n_{year}} s_{a-1,k} d_k \right)$$

8. Compute the ABC fishing mortality rate that establishes the TAC for year *t* of simulation *u*.

   The appropriate fishing mortality rate was determined by the projection year and the relative spawning biomass of the stock as shown in the table below (B_{ref} corresponds to $B_{40\,percent}$ in all cases unless otherwise specified). F_{ref} corresponds to the fishing mortality specified as the F_{ABC} value.

Relative spawning biomass	**Fishing mortality rate**
$B_{t,u} < \alpha B_{ref}$	$F_{t,u}^{ABC} = 0$
$\alpha B_{ref} \le B_{t,u} < B_{ref}$	$F_{t,u}^{ABC} = F_{ref}\left(\frac{B_{t,u}}{B_{ref}} - \alpha \right) / (1-\alpha)$
$B_{ref} \le B_{t,u}$	$F_{t,u}^{ABC} = F_{ref}$

where $B_{t,u} = \sum_{a=1}^{n_{age}} N_{a,t,u} m_a w_a \phi_{a,t,u}$ and $\phi_{a,t,u}$ is the total mortality rate between the beginning of the year and the time of spawning. The value of $B_{t,u}$ was computed iteratively (since it can be a function of fishing mortality). Note also that for some FMPs described below these rules change for some species. For a given FMP *I,* the fishing mortality is treated as a function of the F_{ABC} value.

$F_t^{Alt} = f\left(F_{t,u}^{ABC}\right)$ as specified by the FMP.

9. Compute the TAC value as annually varying limit on catch. For a given species and value of (for $F_t^{Alt_I}$ alternative *I*) the projection model computes the TAC used in the constraint as

$$TAC_t^{Alt_I} = \sum_{k=1}^{n_{sex}} \sum_{a=1}^{n_{age}} N_{a,t} w_{a,k} \frac{F_t^{Alt_I} s_{a,k} d_k}{F_t^{Alt_I} s_{a,k} d_k + M_a^P} \left[1 - e^{-F_t^{Alt_I} s_{a,k} d_k - M_a^P} \right]$$

10. Compute the actual catch, $C_{t,u}$, given the suite of constraints from the LP optimization described below.

11. Solve for the fishing mortality rate $X_{t,u}$ that would set catch equal to $C_{t,u}$ in year *t* of simulation *u* as estimated from the multi-species management constrained optimization problem described below and varies by FMP by solving the following implicit equation:

$$C_{t,u} = X_{t,u} \sum_{a=1}^{n_{age}} \left[N_{a,t} \left(\frac{1 - \exp\left(-M_a - X_{t,u} \sum_{k=1}^{n_{sex}} s_{a,k} d_k \right)}{M_a + X_{t,u} \sum_{k=1}^{n_{sex}} s_{a,k} d_k} \right) \sum_{k=1}^{n_{sex}} w_{a,k} s_{a,k} d_k \right]$$

12. Check to see if all years of simulation *u* have been completed, then continue as necessary:

    If $t<n_{pro}+1$, return to (6)
    If $t=n_{pro}+1$, end simulation *u*.

13. Return to (2) until all simulations are complete.

Step 5: Store Stock Performance Statistics from the Above Projections

A series of individual stock performance indicators for species with specified age-structure results were computed separately for each FMP as follows:

Total biomass in each year and simulation:

$$T_{t,u} = \sum_{a=1}^{n_{age}} N_{a,t,u} w_a$$

Spawning biomass and catch, as specified above, were stored for each species, year, and simulation. Approximate confidence bounds were computed from the simulation output by simply ranking results from the simulations and computing the percentile values corresponding to the desired intervals (here taken as the 10th and 90th percentile). Also computed was the implied spawning biomass per recruit (SPR) rate, given the level of catch in a single year and simulation. (For example, the theoretical percentage of unfished spawning output expected from a single recruit if fishing mortality were equal to the estimated fishing mortality over the life of the species.)

Average age for each stock in the final projection year across all simulations was computed as:

$$A = n_{sims}^{-1} \sum_{u=1}^{n_{sims}} \frac{\sum_{a=1}^{n_{ages}} a\, N_{a,2002+n_{yrs},u}}{\sum_{a=1}^{n_{ages}} N_{a,2002+n_{yrs},u}} + a_{\min} - 1$$

The Linear Programming Algorithm

LP is an active research branch of operation research that has proved to be useful in resource management. In this context, an optimization problem is considered linear if all objective function and constraint coefficients can be arranged in a linear way. The linear optimization problem, in this case, consists of finding the optimal catch allocation in order to maximize the overall catch or total revenue across all fisheries and subject to a certain number of linear constraints. We used a revised Simplex algorithm (Press *et al.* 1992) to find the optimal vertex in this multidimensional space.

The objective function and constraint coefficients were computed primarily from the NOAA Fisheries, Alaska Region blend dataset. The data were averaged over the period 1997 to 2001, so all the coefficients represent averages from this time period. FMP-specific constraints were developed for both the BSAI and GOA. Namely TAC constraints for each FMP area complex, special gear sconstraint for some species, lower and upper bound constraints on the variation of catch relative to average levels for each fishery, and constraints of the maximum allowable biological removals of each system.

Objective Function Coefficients

The target function consisted of coefficients derived from the blend data set for FMP-managed species across different fisheries. The ex-vessel value ($V_{j,g}$) for each species and proportion retained by each fishery were used to compute the coefficients of the linear objective function:

$$A_g = \sum_{j=1}^{n_{species}} \sum_{k=1}^{n_{Areas}} V_{j,g} C_{j,k,g}^{old} R_{j,g}$$

with the overall objective function to be maximized in year t is given as:

$$\Theta_t = \sum_{g=1}^{n_{fish}} A_g Y_{t,g}$$

where

A_g	Objective function coefficients applied to each fishery
$C_{j,k,g}^{old}$	Catch data from the blend dataset by species, sub-area and fishery
$R_{j,g}$	Retained fraction of catch
$Y_{t,g}$	Relative total catch between fisheries within each year (main result returned from the constrained optimization)

$V_{j,g}$ Estimated ex-vessel value of each species within different fisheries

t Year

j Species

k Sub-area

g Fishery

h Gear-type

Linear Constraints

In our optimization problem there are two types of constraints: values that are maxima or upper bounds, and values that are minima or lower bounds. There were five types of upper-bound constraints and one type of lower-bound constraint, these are presented below in consecutive order. The coefficients were computed only once for a specific FMP since the catch-composition data is constant for this model version over time and assumed known without error.

The bounding information or constraints were based on a number of sources detailed below. Note that some constraints change over time (e.g., the ABC/TAC constraints).

Acceptable Biological Catch (ABC/TAC) Constraints

These constraints determined an upper bound equivalent to the TAC for each species in each sub-area. Each constraint has one coefficient and represents the average annual catch by FMP species and area as:

$$\sum_{g=1}^{n_{FMP}} Y_g a_{j,k,g}^{ABC} \leq b_{j,k}^{ABC_t}$$

$$a_{j,k,g}^{ABC} = C_{j,k,g}^{hl}$$

$$b_{j,k}^{ABC_t} = TAC_{t,j,k}\ f_k$$

where $TAC_{i,j,k}$ = Total allowable catch for species j, in sub-area k in year I and f_k is the split by area for a particular species, and the bounds of the constraints are calculated as a function of a fixed allocation fraction of the TAC across sub-areas and the estimates for TAC by year.

Gear Type (G) Constraints

Gear allocations for a specific annual TAC were included to reflect the current practice. In the model, these constraints were specified as

$$\sum_{g=1}^{N_G} Y_{t,g} a_g^G \leq b^G$$

$$a_g^G = \sum_{g=1}^{N_{areas}} C_{k,g}^{bl}$$

$$b^G = TAC_e f_k^G$$

where e = Index for species with gear restrictions

f_k^G = Proportion of TAC allocated to each gear type, G, of each species in sub-area k.

For example, sablefish TAC's are allocated between longline fixed gear and trawl gear. The model accounts for these allocations as added constraints.

Fishery Expansion Constraints

Upper-bound constraints on relative catch are placed by FMP species upper limit (UL) so that relative catch does not grow unreasonably beyond the baseline data or 1997 to 2001 average.

$$Y_{t,g} a_g^{UL} \leq b_g^{UL}$$

b_g^{UL} values typically ranged from 1.3 to 3. However, some alternatives specified different values as detailed in Section 4.1.5.5 Description of the Alternatives.

Fishery Contraction Constraints

Based on extensive initial runs of this model, the optimal solution often eliminated a number of fisheries. To prevent this, and to ensure that the catch remains positive, the following set of lower-limit (LL) constraints were applied.

$$Y_g a_g^{LL} \geq b_g^{LL}$$

where $a_g^{LL_r}$ is a scalar for fishery g.

Overall Optimum Yield (OY) Constraint

The specification that the OY cap could not be exceeded was given as:

$$\sum_{g=1}^{N_{FGE}} Y_{t,g} a_g^{OY} \leq b^{OY}$$

$$a_g^{OY} = \sum_{e=1}^{N_{sp}} \sum_{k=1}^{N_{AREAS}} C_{e,k,g}^{bl}$$

$$b^{OY} = OY$$

where OY = optimum yield summed for the geographical area (e.g., BSAI) for all target FMP species

e = index of target species used for optimum yield.

Note that this was generally two million metric tons (mt) for the BSAI and 800,000 mt for the GOA. However, some alternatives specified different values as detailed below in the FMP descriptions section.

Optimizing the Objective Function Subject to the Constraints

To find the optimum solution in standard tableau notation (Press *et al.* 1992), we can reduce the system of equations to the following array with columns 2 to $g+1$ corresponding to each fishery:

where

m_{ABC} Number of ABC type of constraints (number of species that have TAC)

m_G Number of gear type of constraints

m_{UL} Number of upper limit constraints on relative catch of FMP species

m_{LL} Number of lower limit constraints on relative catch of FMP species

m_{OY} Number of optimum yield constraints (only one)

Some of the coefficients (A_i , a_i^j) are zero but they are presented here in a general notation.

$$
\begin{array}{ccccccc}
0 & A_1 & \cdots & A_i & \cdots & A_g \\
b_{i,j,k}^{ABC_1} & -a_{j,k,1}^{ABC_1} & \cdots & -a_{j,k,i}^{ABC_1} & \cdots & -a_{j,k,g}^{ABC_1} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
b_{i,j,k}^{ABC_{nABC}} & -a_{j,k,1}^{ABC_{nABC}} & \cdots & -a_{j,k,i}^{ABC_{nABC}} & \cdots & -a_{j,k,g}^{ABC_{nABC}} \\
b^{MC_1} & -a_1^{MC_1} & \cdots & -a_i^{MC_1} & \cdots & -a_g^{MC_1} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
b^{G_1} & -a_1^{G_1} & \cdots & -a_i^{G_1} & \cdots & -a_g^{G_1} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
b^{G_{nG}} & -a_1^{G_{nG}} & \cdots & -a_i^{G_{nG}} & \cdots & -a_g^{G_{nG}} \\
b^{UL_1} & -a_1^{UL_1} & 0 & 0 & 0 & 0 \\
\vdots & 0 & 0 & -a_i^{UL_n} & 0 & 0 \\
b^{UL_{nUL}} & 0 & 0 & 0 & 0 & -a_g^{UL_{nUL}} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
b^{OY} & -a_1^{OY} & \cdots & -a_i^{OY} & \cdots & -a_g^{OY} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
b^{LL_1} & -a_1^{LL_1} & 0 & 0 & 0 & 0 \\
\vdots & 0 & 0 & -a_i^{LL_{nLL}} & 0 & 0 \\
b^{LL_{nLL}} & 0 & 0 & 0 & 0 & -a_g^{LL_{nLL}}
\end{array}
$$

4.1.5.3 Data

Estimation of the 1997 to 2001 Catch by Species and Fisheries

We used the NOAA Fisheries, Alaska Region blend estimates of catch by area, species, gear, and target species combined with observer fish ticket data. The fish tickets are landing receipts recorded by Alaska Department of Fish and Game (ADF&G) statistical areas.

The North Pacific Groundfish Observer Program currently provides all of the information we have on fishery interactions with non-target species. Observers estimate total catch and species composition of the catch in a random sample of hauls. All animals are counted, weighed, and identified to the lowest practical taxonomic level, regardless of their status as a target species, or whether they will later be discarded by the vessel. The Observer Program is extensive, covering the majority of fishing effort in the BSAI and up to 30 percent of fishing effort in the GOA.

Despite the large size and extent of the Observer Program, not all fishing is observed at all times. Only fishing vessels over 124 feet (ft) in length must carry an observer for all days fishing. Smaller vessels (60-124 ft) are only required to carry an observer for 30 percent of days fishing, and vessels under 60 ft are never required to carry an observer. Therefore, we had to extrapolate the data collected by observers to the reported catch from all observed and unobserved fishing in order to estimate the total catches of non-target species groups from all fishing for this analysis. This assumes that observed fishing and unobserved fishing have the same catch composition. Although this assumption is unverified, observer data is the best and only source of information on non-target species catch.

Catches were estimated by species group for the recent domestic fishery, 1997 to 2001, using the following method: within each year, each vessel's observed catch of a given species group was summed within statistical area, gear type, and week. A target fishery was then assigned to each vessel's weekly catch, generally by assuming that the species with the highest retained catch for that week was the target species. The Programmatic SEIS describes target fishery designations and the specific algorithm for assigning targets. This is consistent with target assignments done as part of the inseason management system at the regional office. Catch by target species and non-target species, where available, was then summed for each year over all observed vessels within each area, gear, and target fishery. The ratio of observed non-target species catch to observed target species catch within each area, gear, and target fishery was multiplied by the total reported (regional office blend-estimated) target species catch within that area, gear, and target fishery. Data from years prior to 1997 could not be assigned to target fisheries in a way that is consistent with total catch targets assigned by the NOAA Fisheries Alaska regional office due to changes in the structure of the observer database. We do not consider this a problem because the most recent years of catch information are most valuable for the purposes of this analysis. Catches of other species, forage fish, and grenadiers were estimated for 1990 through 2001 as part of the annual stock assessment process and are reported in annual SAFE documents for the BSAI and the GOA.

The catch-composition data were processed to reflect area and time closures specific to each alternative. Since the catch-composition estimates were assigned to spatial/temporal strata, then the effect of changes in management measures could be reflected by modifying the catch-composition arrays accordingly. For example, if an alternative had specific closed areas, then the catch-composition data that fell within those

categories were deleted. The notion here was simply to try to reflect how catch-composition might change under alternative area-time constraints.

Methods Used to Apportion the Estimates of Total Catch, Retained Catch, and Ex-Vessel Value by Processor Group and Vessel Class and to Estimate Product Value by Processor Group

We used blend estimates of total catch and retained catch and fish ticket estimates of retained catch for 1999 to 2001 to apportion the catch and ex-vessel value projections discussed above by processor group and vessel class. The resulting estimates of retained catch by processor group were used with 2001 estimates of product value per mt of retained catch to generate the estimates of product value. The methods used are discussed below.

Step 1: Define Processor Groups and Identify the Processors in Each Group

We defined the following six groups of inshore processors and six groups of at-sea processors to assist in analyzing the economic and social effects of the GOA and BSAI groundfish fisheries both historically and for the alternatives being considered in this Programmatic SEIS.

1. Large BSAI pollock processors (the American Fisheries Act [AFA] inshore sector processors that operate in or near Unalaska and Akutan.

2. Other Alaska Peninsula and Aleutian Island processors.

3. Floating processors (non-AFA floating processors).

4. Kodiak processors.

5. Southcentral processors.

6. Southeast processors.

7. Surimi factory trawlers.

8. Fillet factory trawlers.

9. Head and gut factory trawlers.

10. Longline catcher processors.

11. Pot catcher processors.

12. Motherships.

We then identified the processors in each of these mutually exclusive groups.

Step 2: Distribute Catch and Ex-vessel Value Projections by Processor Group

We used blend estimates of total catch and retained catch by fishery, species (for the TAC species), and processor group from 1999 to 2001 to estimate the shares of total catch and retained catch by fishery and species associated with each processor group. The fisheries were defined by target species, gear, and area. We then applied the total catch shares to the alternative-specific total catch projections to estimate alternative-specific total catch by fishery, species, and processor group. The retained catch shares were used in a similar way with the alternative-specific retained catch and ex-vessel projections to generate comparable estimates of retained catch and ex-vessel value. Data for 1999 to 2001 were used because the AFA was implemented in 1999, significantly changing the shares of catch among processor groups.

Step 3: Estimate Product Value by Processor Group

For each inshore processor group, we used 2001 Alaska Commercial Operator's Annual Report (COAR) estimates of groundfish purchases and product value by species to estimate product value per mt of retained catch. For each at-sea processor group, we used 2001 COAR product price data for at-sea processors, supplemented by 2001 product price data provided by representatives of the Head and Gut Factory Trawlers, together with Weekly Production Report production and retained catch data to estimate product value per mt of retained catch.

Step 4: Define Catcher Vessel Classes and Identify the Catcher Vessels in Each Group

We defined the following nine classes of groundfish catcher vessels to assist in analyzing the economic and social effects of the GOA and BSAI groundfish fisheries both historically and for the alternatives being considered in this Programmatic SEIS.

Bering Sea pollock trawl catcher vessels greater than or equal to 125 ft in length

- Bering Sea pollock trawl catcher vessels 60 to 124 ft in length.
- Diversified AFA-eligible trawl catcher vessels greater than or equal to 60 ft in length.
- Non-AFA trawl catcher vessels greater than or equal to 60 ft in length.
- Trawl catcher vessels less than 60 ft in length.
- Pot catcher vessels less than or equal to 60 ft in length.
- Longline catcher vessels less than or equal to 60 ft in length.
- Fixed gear catcher vessels 33 to 59 ft in length.
- Fixed gear catcher vessels less than or equal to 32 ft in length.

We then identified the catcher vessels in each of these mutually exclusive vessel classes.

Step 5: Estimate Retained Catch and Ex-vessel Value by Catcher Vessel Class

We used State of Alaska fish ticket estimates of retained catch by species, area, processor group, and vessel class from 1999 to 2001 to estimate the share of retained catch by species and area associated with each catcher vessel class. We then applied the retained catch shares to the alternative-specific retained catch and ex-vessel value projections by processor group to generate alternative-specific estimates of retained catch and ex-vessel value by species, area, and catcher vessel class.

Assumptions

The resulting estimates of total catch, retained catch, ex-vessel value, and product value are based on the assumptions that the following will not vary, either by alternative or from what has been observed recently for the BSAI and GOA groundfish fisheries:

- Species composition (i.e., bycatch rates) of TAC species in any individual fishery, where a fishery is defined by area, gear, and target species.
- Distribution of catch among processor groups in any individual fishery.
- Retention rates for a fishery, species, and processor group.
- Product mix for a species and processor group.
- Distribution of retained catch among catcher vessel classes for each processor group.
- Ex-vessel prices.
- Product prices.

We do not believe these assumptions are either equally valid for all the alternatives or valid for most of the alternatives. Unfortunately, the information necessary to estimate alternative-specific differences in bycatch rates, the distribution of catch among processor groups and vessel classes, retention rates, product mix, ex-vessel prices, or product prices is not available. This problem is addressed qualitatively in the sections that present the projections of ex-vessel value and product value for the various alternatives.

Estimates of Ex-Vessel Value Per Metric Ton of Retained Catch

We used 2001 Alaska COAR groundfish purchase data to estimate ex-vessel value per mt of catch by species, gear, and area for the species that are not almost exclusively processed at sea. For the other species, such as BSAI Atka mackerel, flatfish, and rockfish, we estimated that the ex-vessel value per mt of retained catch was 40 percent of the product value per mt of retained catch.

Description of the Fishery Definitions Used in the Model

In the GOA, 32 different fisheries were defined as having gear-area-target significance. These are listed in Table 4.1-14. Table 4.1-15 lists the 35 fisheries defined for the eastern BSAI regions (Figures 4.1-2 and 4.1-3).

To summarize characteristics of each ,fishery we devised a method to show the diversity of species mix observed in the catch. We used Simpson's (1949) index of diversity (κ) commonly used in population biology. For each fishery the index is computed as

$$\kappa = \frac{1}{\sum_{i=1}^{nspp} p_i^2}$$

where p_i is the proportion of catch in biomass over all species or species groups (55 different categories in the GOA and 56 in the BSAI). This index can be interpreted as roughly the effective number of species. For example, Figure 4.1-4 illustrates a hypothetical catch composition of five species caught in four different fisheries at different proportions. The effective number of species for Fishery A is very close to 1.0 (1.02) due to the fact that 99 percent of the catch is attributed to Spp_1. At the other extreme, Fishery D caught all five species in equal proportions leading to an index value exactly equal to 5. In Fishery B, only two species are caught in equal proportion, hence the effective number of species is exactly 2. In Fishery C, all five species occur, but in diminishing proportions; therefore, the effective number of species is slightly lower than 3.

Presenting the species mix for fisheries in this way provides a simple way of examining the differences between fisheries. More importantly, it can be used to show the effect of how sampling variability and time trends may affect the estimated catch composition of each fishery. For example, computing the effective number of species using five-years of NOAA Fisheries blend data in aggregate average catch by species and fisheries showed that for both the GOA and BSAI regions, flatfish and rockfish fisheries tend to have higher catch diversity, since these are fundamentally mixed-species fisheries. Pollock fisheries and fisheries using pot gear tended to have the lowest diversity (Figures 4.1-5 and 4.1-6). However, these figures show that the catch diversity in some fisheries can be quite different between years. This is presumably largely due to sampling error and partly due to real changes in catch composition. Another contribution to this variability could be how target fisheries are defined. (i.e., a target fishery is defined based on the dominant species catch reported by week). If a vessel actually targets multiple species within a week, then the diversity of the reported catch may be unrealistically high. These factors highlight important caveats regarding the ability to accurately predict how catch diversity levels may change from one year to the next. These problems would be exacerbated by using subsets of catch composition data within years that have closed areas. For this reason, we chose to assume that the best available estimates of fisheries catch composition were based on data aggregated from 1997 to 2001. Since many of these fisheries defined may reflect relatively small levels of catch, we evaluated this index for the major fisheries and examined the trend over time. For the GOA, 11 of the 32 fisheries represented 80 percent of the catch. These fisheries still had considerable inter-annual variability in catch diversity (Figure 4.1-7), but no apparent trend. In the BSAI, 8 fisheries represented 91 percent of the catch and had less inter-annual variability (Figure 4.1-8). The flatfish fisheries appeared to have a slightly increasing trend in diversity from 1997 to 2001. This suggests that the assumption of constant

species compositions may be inappropriate. Further research on what has caused this apparent trend in catch diversity is warranted.

4.1.5.4 Critique of Assumptions and Approach

Forecasting fisheries behavior is an endeavor fraught with uncertainty. Even under a relatively constant management system, changes in socioeconomic and environmental conditions can result in substantial future uncertainty. Add in a complex set of alternative management measures, such as those presented in this document, and the uncertainty is magnified. The following describes an attempt to model key aspects of the current fisheries management system and, to the extent possible, modifications according to the specific management measures for the four alternatives and their range. The model's predictive power given the system complexity is poor. However, this multi-species technical interaction model does provide a more objective approach to evaluate alternative management actions compared to single species examinations.

The NPFMC Scientific and Statistical Committee (SSC) provided feedback on the modeling approach. In particular, they raised a number of concerns about using this type of approach (i.e., using LP to mimic fisheries management). For example, using ex-vessel value estimates as part of the objective function fails to reflect the costs. Unfortunately, extensive cost data are unavailable. The SSC noted that ex-vessel prices are likely to change over time. While modeling how these may change over time would be valuable, the degree of difficulty and added complexity prohibited development along these lines. This aspect seems unlikely to have a large-scale effect over the five-year simulation projection.

Within alternatives, the catch-composition array is assumed to be constant. That is, there is no random variability, nor are there trends in the underlying catch composition within a fishery. In reality, catch-composition values are likely to vary from year to year. Observation error and other sources of variability and potential biases mask this variability. The model was developed so that catch-composition variability can be implemented in the simulation. However, since available data are limited to five years, the magnitude of this uncertainty could not be assessed in time for this analysis. Explicitly modeling the catch composition of each fishery is an area of research that needs to be pursued, particularly as dynamic species interactions are introduced.

The fact that the catch-composition array is constant over time may not be unreasonable given the short time frame of the main projections (2003 to 2007). However, the long-term projections assess conditions to 2023; these results should be viewed much more cautiously. These long-term projections were done to provide some indication of general trends between stocks. For the five-year time frame used for estimating the catch composition by fisheries and species matrix (1997-2001), there appeared to be little or no trend in the diversity of the catch for the main fisheries (e.g., Figure 4.1-8). The annual variability in the diversity of the catch highlights the importance of including details on the effect of area closures on catch by species and fisheries matrices. Clearly, sampling error plays a large role, and, as finer geographic resolution is included, the effect of sampling error will increase. This will likely compromise real changes in bycatch patterns due to area closures.

The uncertainty in current abundance levels is not modeled. The point estimates for parameter values (e.g., the numbers-at-age) in the assessments published in the 2002 SAFE are used. This clearly underestimates the variability in the current abundance levels for all species of groundfish. Under FMP 3.2, estimation uncertainty is accounted for and is applied as a risk-averse adjustment. It is possible to add this type of

estimation uncertainty explicitly within the projection model. However, time limitations and the additional complexity in the presentation of the results would detract from the analysis.

Another factor that tends to underestimate variability to some extent is the omission of stock-recruitment relationships from the projection model. The reason for this omission is that, with the exception of EBS walleye pollock, reliable estimates of the stock-recruitment relationship do not exist for any BSAI or GOA groundfish stock. When making projections over the long-term, omission of the stock-recruitment relationship will tend to understate the impacts on biomass and recruitment resulting from a sustained change in the harvest rate. However, when projections are restricted to the near future, as they are for the most part in this document, it is less likely that omission of the stock-recruitment relationship will bias results significantly unless one or more of the following conditions holds: 1) the stock-recruitment relationship for a stock is extremely strong, 2) the average lifespan of individuals in a stock is extremely short, or 3) the average harvest rate for a stock is extremely different from that which generated the initial conditions. Examination of existing stock-recruitment data for BSAI and GOA target groundfish stocks indicates that none of them appear to exhibit extremely strong stock-recruitment relationships, which is one of the reasons why it has proven so difficult to estimate such relationships in the past. Furthermore, none of the BSAI or GOA target groundfish species is extremely short-lived. Finally, while the average harvest rates for Alternatives 2 through 4 typically differ to some extent from the average harvest rates in Alternative 1, the only cases in which the differences are truly extreme occur under Alternative 4. Therefore, it is unlikely that omission of the stock-recruitment relationship will lead to significant biases in the results, with the possible exception of results pertaining to stocks whose average harvest rates under Alternative 4 diverge sharply from the corresponding average harvest rates under Alternative 1.

The SSC also recommended that alternative objective functions be considered. They noted that the purpose of the model is to project likely management actions under the alternatives. Hence, it might be useful to express the objective as a minimization of the weighted sum-of-squared deviations between actual and target levels of catch, where the weights reflect management preferences for meeting TACs. This would provide a non-linear, quadratic objective function with linear constraints, and would add a seemingly desirable feature to the model, at least for the status quo (FMP 1) specification. Time limitations precluded implementation of a Quadratic Programming approach. Furthermore, this approach would require subjective specification of the weights for the different alternatives. For the Linear Programming approach used here, the imperfect objective function requires fewer assumptions about how weights may change by alternative.

For this implementation, the results were largely insensitive to the objective function specification. Some of the assumptions that constrained the solution space most severely were limits placed on the ability of individual fisheries to expand and contract relative to the patterns observed during 1997 through 2001. Sensitivity analysis showed that as these bounds were relaxed, the overall catch and revenue based on ex-vessel value increased at the expense of greater departures from the status quo, and increased sensitivity to the objective function. For these sets of model specifications, bounds were selected based on discussions with economists in the iterative process of examining model results. There is clearly room for improvement in specifying these sets of constraints. One approach would be to poll a wider group of experts to arrive at more refined sets of limits. Such a setting would also provide needed feedback for model improvements and may provide insights to management on the relative benefits of different fisheries.

In summary, the complex interactions among changes in biomass levels, fisheries economic performance, and management effectiveness are just some of the reasons why any such forecast must be viewed cautiously.

4.1.5.5 Description of the Alternatives

The projection model was designed to approximate the general patterns of catch that might be expected given the multi-species nature of groundfish fisheries. The analyses rely on two main sources of information: observer and fish ticket data, the blend data and stock assessment estimates of population parameters, abundance-at-age in 2002, and recruitment variability. The first step in developing model configurations for each of the example FMPs was to process the observer catch-composition data to reflect, to the extent possible, the impact of each FMP. The baseline catch-composition data was derived from observer and fish ticket reports for the period 1997 through 2001. For certain fisheries where characteristics changed dramatically, such as the implementation of the AFA in 2000, the number of years included differed from this baseline. The details of estimating the catch-by-fisheries data used in the model is presented in a separate section below.

The second part of setting up alternative specifications involved limiting TACs either through different harvest control rules or specific ABC reductions. The following sections provide some descriptions about how the model is affected by the different alternatives.

For the main reported species, the PSC species and the other non-target species have been compiled for gear-area-target fisheries using 1997 to 2001 as the baseline average. For all FMPs, except FMP 2.2, the EBS pollock fishery and the Aleutian Islands Atka mackerel fisheries, the average of 2000 and 2001 data were used to better reflect the AFA and other recent management measures. Unless otherwise noted, the values for retention rates are shown in Tables 4.1-16 and 4.1-17, while the estimated average ex-vessel price by species and gear type is given in Tables 4.1-18 and 4.1-19. The catch by species and fisheries for the GOA and BSAI is available from the web (www.fakr.noaa.gov/sustainablefisheries/seis/data). An overview of the key differences between the alternatives as modeled is given in Table 4.1-20. It is important to note that yield and biomass results for any alternative cannot typically be attributed to any single aspect of alternative specification since all aspects are being implemented simultaneously.

FMP 1

This alternative is considered the baseline status quo relative to the 2001 fishing year. The ABC follows Amendment 56 for setting quotas. Furthermore, the ABC setting for FMP 1 is adjusted downward as appropriate and is typically based on recommendations from assessment authors and NPFMC.

For example, in the 2002 SAFE, the ABC fishing mortality for a number of species was set at $F_{t,u}^{Alt1} = \omega F_{t,u}^{ABC}$ where ω is 0.87 for Pacific cod in both the BSAI and GOA. For pollock ω is an added buffer added as a function of spawning biomass, as presented in the GOA pollock SAFE by Dorn *et al.* (2002). For non-Steller sea lion forage species $\alpha = 0.05$, while for pollock, Pacific cod, and Atka mackerel, $\alpha = 0.5$. In the BSAI, an overall OY cap of 2 million mt of groundfish catch was an added constraint, while for the GOA the cap was set at 800,000 mt (FMP species only).

FMP 2.1

For this alternative, the catch-composition data are the same as FMP 1, with one exception: the pre-Individual Fishing Quota (IFQ), catch-composition rates for sablefish fisheries and earlier estimates of halibut mortality

were used. The use of earlier data represents only a small difference when compared to the current estimates; and is available on the website (www.fakr.noaa.gov/ sustainablefisheries/seis/data). The F_{ABC} for this FMP is set equal to F_{OFL}, or the overfishing level (OFL), which, by NPFMC definitions, equals the point estimate of F_{msy}. This fishing mortality rate is held constant over all stock sizes, including as the stock drops below $B_{40\%}$ (i.e., $F_{t,a}^{ABC} = F_{msy}$ for $B_{t,a} > 0$). For all age-structured stocks, the F_{msy} was set equal to the SPR fishing mortality rate of $F_{35\%}$. For survey biomass stocks Tier 4 through 6 from Amendment 56, the ABC was set equal to the overfishing level (OFL). Additional measures for Steller sea lion prey species were omitted.

In FMP 2.1, the OY is set to the sum of ABC's in both the GOA and BSAI. Also, there are no constraints due to PSC limits. For example, bycatch of Pacific halibut will not constrain fishery development. The fishery-expansion constraint is set to 100 (i.e., fisheries can expand effort beyond the average level observed over 1997 through 2001).

FMP 2.2

Example FMP 2.2 is similar to FMP 1, except that the OY is set to the sum of ABCs in both the GOA and BSAI, instead of at a fixed cap. Also, the maximum permissible ABC value was used instead of the author's adjustment (see ☙ for FMP 1).

FMP 3.1

This FMP is similar to FMP 1, except that the constraint on Pacific halibut mortality is reduced by 10 percent and, therefore, more constraining. Also, the author's recommendation for ABCs (see ☙ for FMP 1) is omitted (e.g., the GOA pollock OFL buffer).

FMP 3.2

For example FMP 3.2, catch species by fishery data are modified to reflect improved rationalization. That is, the bycatch of discarded species is reduced by using existing total catch estimates and changing the fraction that is discarded. Specifically, for given species and fishery, the catch that has been estimated as being discarded in the data will be reduced by 20 percent. This means that under fisheries rationalization, the fishing behavior will change such that the actual incidental catch will be reduced. This change is implemented by modifying the input data on catch species by fishery and is sometimes referred to as the bycatch matrix. These data are available on the NOAA Fisheries website: http://www.fakr.noaa.gov/sustainablefisheries/seis/data.

Another aspect of improve rationalization specifies that the retention rates of what is caught in the future will increase; in other words, at which species are discarded the rate will be reduced 20 percent. This change is implemented by modifying the retention rate matrices for GOA and BSAI shown in Tables 4.1-21 and 4.1-22.

For example FMP 3.2, the OY is set to the sum of ABCs instead of the current 2 million mt capacity. Also, the halibut mortality limit is reduced by 30 percent relative to FMP 1.

One objective under FMP 3.2 was to incorporate formal estimates of uncertainty already estimated in many of the stock assessments. A large-scale research effort on developing methods to use fully Bayesian risk-averse methods is in progress, and a version of this development is used here.

Under the current system a common assumption is that the $F_{35\,\%}$ rate is a good proxy for F_{msy}, and thereby determines the F_{OFL}. Similarly, $B_{35\,\%}$ is commonly taken as a good proxy for B_{msy}. Given the parameter values from stock assessment results to determine these quantities, the NPFMC has implicitly accepted that the $F_{40\,\%}$ fishing mortality rate is suitably risk-averse regardless of uncertainty in future recruitment and current stock size. The risk-averse adjustment to the F_{msy}, here assumed to be $F_{35\,\%}$, formally accounts for the uncertainty in current stock size and future recruitment. In addition to the standard selectivity, average mass-at-age, natural mortality, current numbers-at-age, and maturity-at-age schedules, the method developed requires estimates of the covariance matrix of the current numbers-at-age and the time series of recruitment estimates. The advantages of the method developed include: 1) that the upper bound of the F_{ABC} is set to a constant level of risk-aversion; 2) simulations to determine the appropriate adjustment level can be avoided; 3) analytical solutions are available for all steps except one final maximization; and 4) the ability to assess the value of improving estimates and reducing variance of current stock size. A key feature of this analysis is the development of a method for calculating the stock-recruitment relationship given estimates of B_{msy} and F_{msy} and the other age-specific schedules listed above. The actual values for the adjustment are shown in Table 4.1-23 and a presentation of two scenarios where the risk-averse adjustment appears to be due to different sources is shown in Figure 4.1-9.

The application of the risk-averse adjustment was applied for all stocks:

$$F_{Har} = F_{msy} * \text{Adjustment}$$
$$F_{ABC} = \min(F_{Har}, F_{40\,\%}, F_{OFL_Alt1})$$

While for rockfish species an added measure of precaution was applied where

$$F_{ABC_RF} = \min(F_{60\,\%}, F_{Har})$$

FMP 4.1

In this example FMP, the OY constraint is set to the sum of ABCs. Note that this is effectively the same as omitting an OY constraint since the individual species" ABCs are constraints themselves. The species catch by fishery was modified so that fisheries with more than 33 percent bycatch of a species not listed as the target specie was eliminated. Pacific cod, pollock, and arrowtooth flounder were not included as a bycatch species to these fisheries.

Uncertainty corrections to the ABCs were based on survey catcher vessels Also, the F_{ABC} was set to $F_{75\%}$ for all Steller sea lion prey species and for all species of rockfish. Note that uncertainty corrections applied to the $F_{75\,\%}$ values, too.

Agency analysts discussed how to incorporate the formal estimates of uncertainty already estimated in some of the stock assessments (e.g., AD Model Builder applications or Bayesian analyses). This is an ongoing area of research; however, the example regime was deliberately designed to be applicable to all stock assessments regardless of the software used. Incorporating formal estimates of uncertainty available for some stocks

would continue to impose the largest adjustments only on the best known stocks. For example, the current process for TAC setting does not reduce harvest levels when the reference biomass level ($B_{40\%}$) cannot be estimated for stocks in Tiers 4 to 6 of Amendment 56/56 ABC and OFL definitions. Stocks qualify for management under Tiers 4 to 6 only if reference stock levels cannot be estimated reliably.

The formal incorporation of uncertainty was accomplished by setting the fishing mortality rate associated with ABC (F_{ABC}) at specified fractions of the maximum allowable fishing mortality rate maximum F_{ABC}. This fraction varies directly with the uncertainty or variance of the survey biomass estimates. Specifically, this is accomplished by computing the average coefficient of variation for the survey biomass estimates in the time series and then computing the lower bound of the 90 percent confidence interval for a lognormal distribution with this coefficient of variation and a median of unity. This lower bound is the specified fraction by which to reduce maximum F_{ABC}. The specified fraction by which to reduce maximum F_{ABC} is provided as input to the model for FMP 4.1. All target species with biomass estimates were analyzed. Exceptions are made in the model projections for some species whose stock assessment F_{ABC} is below maximum F_{ABC}. These adjustment values, corresponding to the lower bound of the 90 percent confidence interval, are given in Table 4.1-24.

For FMP 4.1, the prohibited species cap for Pacific halibut mortality was reduced to 50 percent of the current level, causing a higher level of constraint.

FMP 4.2

No fishing was allowed for the 5 year-projection. We presume that under this example FMP, fisheries authorized following review would take the form of that regime being illustrated by FMP 4.1.

4.1.5.6 How Model Results Were Applied in Assessing Impacts of the Alternatives on Different Resources

Target, Forage, Prohibited, Other, and Non-Specified Species

For the target species, the multi-species, multi-fisheries simulation projection model provided fundamental dynamics to the model behavior. That is, as the biomass of an FMP species changed in the future, the constraint via ABC/TAC control also changed. The outputs from the model were primarily intended to reflect these dynamics and the interactions with the species composition of the different fisheries.

The significance of the impacts on target species were evaluated with respect to fishing mortality, change in biomass level, spatial/temporal concentration of the catch, prey availability, and habitat suitability.

The significance of the effects of the alternative fishing mortality levels are evaluated with respect to the overfishing mortality rates as set forth in Amendment 56/56. Fishing mortality rates that exceed the overfishing mortality rate are considered to jeopardize the capacity of the stock to produce MSY on a continuing basis and adversely impact the sustainability of the stock. A related measure of this potential is indicated by change in biomass levels. The significance of effects of the current spatial/temporal concentration of the catch and the level of prey availability and habitat suitability for target species are evaluated with respect to each stock's current size relative to its MSST. An action that jeopardizes the stock's ability to sustain itself at or above its MSST is considered to adversely affect the sustainability of the stock.

Species or species complexes that fall within Tiers 1 though 5 have estimates of the current fishing mortality rates, and are evaluated with respect to exceeding the overfishing mortality rate or fishing mortality effect. Species or species complexes that fall within Tiers 1, 2, or 3 have reliable estimates of MSST, and are evaluated for the effects of spatial/temporal concentration of the catch, prey availability, and habitat suitability. Species or species complexes that fall within Tiers 4, 5, or 6 do not have reliable estimates of MSST; therefore, we cannot evaluate the significance of these effects. This inability to evaluate the significance of the effects occurs for the forage, prohibited, and non-specified species. Since several species or species complexes do not have estimates of abundances-at-age, in this version of the model, their abundance levels simply reflect the most recent estimate. For these groups, analysis of the effects of the example FMPs were limited to catch projections and likely consequences given patterns in related fauna.

Habitat

A quantitative estimate of habitat impact under each example FMP requires an estimate of the fishing effort applied in areas remaining open under each scenario. The amount of effort should take into account the catch levels expected under the alternatives in each TAC management area and the amount of catch taken under the baseline that would have been taken inside and outside the area to be closed by the FMP. Because of the limitations in the multi-species bycatch model, not all species and their area-specific catches are easily explained by the stock dynamics. The impact of alternative-specific management practices on model outputs are also difficult to interpret on detailed area fishery and species scales. While stockwide projections of most major species are more easily understood, catch by TAC management area is required for the effort estimation. The time required to complete a rigorous analysis to validate, and in some cases correct, area-specific catch levels exceeds the time available to prepare this Programmatic SEIS. This necessitated a more qualitative evaluation in this Programmatic SEIS of the expected impacts on habitat based on known fishery characteristics.

Seabirds

The analysis of direct and indirect effects on seabirds relies on the projection model's estimates of fishing effort in mt by different gear types in the BSAI and GOA under the different FMP bookends. Hook-and-line or longline and trawl effort are particularly important for analysis of incidental take. For analysis of FMP 2.1, the projection model's output essentially eliminates the BSAI longline cod fishery and triples the GOA longline cod fishery, and is based on small price differentials between gear types. This situation is considered an unrealistic artifact of the model's rules for allocating catch between gear types in lieu of specified allocations. For FMP 2.1, the BSAI longliners are assumed to take about the same volume of cod as they have under the baseline conditions, with the balance going to trawl and pot gear. For the GOA, longliners are assumed to take the same percentage of the cod TAC as they had under the baseline, which translated into a moderately higher catch because of the higher TAC. The implications of different spatial/temporal restrictions are also analyzed, especially as they relates to effects on prey availability for nearby seabird colonies and potential for trawling in critical habitat areas of eiders. Other factors that were not modeled, including implementation of seabird protection measures and the potential for a directed forage fish fishery, were also included in the analysis.

Marine Mammals

Results from the multi-species management model are used to analyze the effects of the example FMPs on marine mammal populations. Catch projections from the model are used to estimate incidental take of marine mammals and to evaluate harvest levels of marine mammal prey species. Total projected groundfish catch was averaged from 2003 to 2007 for each example FMP. This average projected catch is multiplied by the incidental take rate, calculated as marine mammal takes/mt of groundfish of each marine mammal species as derived from Angliss *et al.* (2001), to estimate changes in incidental take under each example FMP. The average annual fishing mortality rate (F) projected from 2003 to 2007 is compared to the baseline (2002) to determine the change in F expected under each alternative bookend for all key marine mammal prey species. Percent changes in F relative to the baseline were used to indicate changes in the prey field for affected marine mammal species. These analyses employ unmodified model results as they were reported and, therefore, incorporate all the assumptions that went into the model.

Socioeconomic

The output from the multi-species management model is used as the starting point for development of the socioeconomic impact model, referred to in the remainder of the document as the Sector Model. The Sector Model uses the multi-species management model output of catch of each species by gear in each area. The Sector Model distributes those catches and associated values, as well as income and employment, to the various fishing and processing sectors that depend on the groundfish resources, and to the geographic regions where the activities occur and where factor owners reside. A detailed description of the Sector Model is included in Section 4.1.7.

Ecosystem

The multi-species bycatch model is used to derive indicators for assessing the impacts of the alternatives on the ecosystem. The indicators chosen are ones that would characterize changes in predator/prey relationships, energy flow, and diversity. In predator/prey relationships, model outputs are used to obtain estimates of pelagic forage biomass of target species, such as the walleye pollock and Atka mackerel in the BSAI, and walleye pollock in the GOA. Total biomass of these species is used to derive this index. Bycatch estimates of squid, herring, and the managed forage species group from the model are used as another indicator of the magnitude of fishing impacts on these other forage species. Trophic level of the catch is an indicator of fishing down the food web, which is the sequential fishing down of species high in the food chain, such that over time the fisheries are left only with mid-trophic level species as targets. Model estimates of catch biomass for each target and nontarget species group are combined with estimates of trophic level of each species group, derived from food habits information to obtain estimates of the overall trophic level of the catch for each example FMP. Fishing effects on top predator species are evaluated through model estimates of bycatch of sharks and birds. Model estimates of total retained catch, and discards for target and nontarget species, are used as an indicator of the effects of the alternatives on energy cycling characteristics of the ecosystem through energy removal or total retained catch, and/or energy redirection discards. Finally, model estimates of bycatch of HAPC biota were used as an indicator of effects of fishing on functional structural habitat diversity.

Glossary of symbols used in description of the model

Dimensions

a_{max}	Maximum age used in the model (plus group)
a_{min}	Minimum age used in the model
n_{age}	Number of ages in the model
n_{gear}	Number of gear types for which separate selectivity schedules are used (as in the assessments)
n_{pro}	Number of years to project beyond the initial year in each simulation
n_{sims}	Number of simulations
n_G	Number of gears with allocation constraints
n_{Fsh}	Number of fisheries
n_{sp}	Number of species
n_{area}	Number of management areas defined for each species

Indices

a	Relative age index, $1 \le a \le n_{age}$
g	Fishery index, $1 \le g \le n_{Fsh}$
k	Sub-area
h	Fishing gear type
t	Projection year index, $1 \le t \le n_{pro}$
u	Simulation index, $1 \le u \le n_{sims}$
I	Alternative index
j	Species index

Life History and Fishery Parameters

d_h	Proportion of total instantaneous fishing mortality rate distributed to gear h
M_a	Natural mortality rate at age a
m_a	Proportion of age a fish that are mature
w_a	Weight-at-age a in the population
p	Proportion of females in the population
$s_{a,h}$	Selectivity of gear type h for fish of age a (scaled so that max(s)=1)
$w_{a,h}$	Weight of age a fish as sampled by gear h

Other Parameters and Expressions Used in Projections

SPR	Spawning biomass per recruit
ABC	Acceptable biological catch
TAC	Total allowable catch
OY	Optimum yield summed for the geographical area (e.g., BSAI) for all target (FMP) species
B_{ref}	A parameter of the control rules used to set the overfishing rate and to constrain F_{ABC}
$B_{t,u}$	Spawning biomass in projection year t of simulation u
C_{2002}	Actual catch observed in 2002 (or projected to be caught)

$C_{t,u}$ Catch in projection year t of simulation u for each population after the LP

$F_{t,u}$ Fishing mortality rate in projection year t of simulation u for each population

F_{lim} A parameter of the control rule used to set the overfishing rate

F_{ref} A parameter of the control rule used to constrain F_{ABC}

$X_{t,u}$ Fishing mortality rate in projection year t of simulation u for each population after the LP

$\phi_{a,t,u}$ Total mortality rate between the beginning of the year and the spawning period

$N_{a,t}$ Numbers at age a in projection year t

$N_{a,t,u}$ Numbers at age a in projection year t of simulation u

n_a Numbers at age a in 2002

$O_{t,u}$ Rate of fishing mortality that constitutes overfishing in projection year t of simulation u

P Probability of overfishing in at least one year of the projection period

R_{2003} Recruitment for 2003 predicted in the 2002 stock assessment

$R_{t,u}$ Recruitment in projection year t of simulation u

$T_{t,u}$ Total biomass (between ages a_{min} and a_{max}) in projection year t of simulation u

TAC_{2002} TAC actually specified for 2002

$X_{t,u}$ Fishing mortality rate that sets catch in projection year t of simulation u equal to C_{max}

A Average age for each stock in the final projection year across all simulations

f_k Proportion of the catch allocated to sub-area k for a particular species

Parameters and Expressions

Θ_t Total objective function value

m_{ABC} Number of ABC type of constraints (number of species that have TAC)

m_G Number of gear type of constraints

m_{UL} Number of upper limit constraints on relative catch of FMP species

m_{LL} Number of lower limit constraints on relative catch of FMP species

m_{OY} Number of optimum yield constraints (only one)

A_g Objective function coefficients applied to each fishery

$C^{bl}_{j,k,g}$ Catch data from the blend dataset by species, sub-area and fishery

$R_{j,g}$ Retained fraction of catch

$Y_{t,g}$ Relative total catch between fisheries within each year (main result returned from the constrained optimization)

$V_{j,g}$ Estimated ex-vessel value of each species within different fisheries

Computation of SPR values

SPR values are computed using species-specific demographic values (see www.fakr.noaa.gov/sustainablefisheries/seis/data), fishing mortality rates (e.g., $F^{\%}_{40\%}$) that would reduce the

female spawning stock (per recruit) to some fraction of the unfished level. The age-specific factors are selectivity, natural mortality, maturity, and weight or fecundity. For example, to compute $F^{p}_{40\%}$, an algorithm to solve the following set of implicit equations was used:

$$0.4B^{p}_{100\%} = \sum_{a=1}^{x^{o}_{\square\square}-1}\left[W^{p}_{a}\, m^{p}_{a}\prod_{j=2}^{a} e^{-\left(M^{o}_{i-1}+F_{\square}s^{o}_{i-1}\right)}\right] +$$

$$W^{p}_{x^{o}_{\square\square}}\, m^{p}_{x^{o}_{\square\square}}\prod_{j=2}^{x^{o}_{\square\square}} e^{-\left(M^{o}_{i-1}+F_{\square}s^{o}_{i-1}\right)}\left(1-e^{-M^{o}_{n^{o}_{\square\square}}-F^{o}_{\square}s^{o}_{n^{o}_{\square\square}}}\right)^{-1}$$

where $B^{p}_{100\%}$ corresponds to the spawning stock per recruit of population p in an unfished equilibrium state. This information was used within the management rule that determines the quota. For some species and alternatives different F-spr rates were used.

4.1.6 Habitat Impacts Model

To evaluate the impacts of fishing on living habitat, the model developed by Fujioka (2002) is used. This model incorporates basic factors determining impacts of fishing on habitat. Given either estimated or assumed values of fishing intensity, where f equals the absolute effort in area swept per year divided by the area size, q_H equals sensitivity of habitat to fishing effort, ρ equals habitat recovery rate, the model predicts a value of equilibrium (i.e., long-term) habitat level, H_{eq}, as a proportion of the unfished level, H_0.

$$H_{eq} = H_0 \cdot \rho\, S/(I + \rho\, S) \qquad \text{where } H_0 = \text{unfished habitat level, } I = f\, q_H \text{, and } S = e^{-I}.$$

Habitat impact or effect level, E, for the given effort, sensitivity, and recovery rates, would be 1- H_{eq}. Letting $H_0 = 1.0$, then

$$E = I/(I + \rho\, S)$$

Various habitat features could be impacted by fishing gear. Initially, this analysis focused on the impact to the biostructure habitat feature of living habitat composed of organisms such as soft corals, tunicates, and sponges with assumed recovery rates of 2 to 15 years. Where applicable, we attempted to address impacts to living habitat with slower recovery rates (i.e., 200 years), such as gorgonian corals (e.g., red tree coral, Primnoa). A widely accepted management policy has been to avoid impacting such long-lived organisms.

Habitat Sensitivity Rate (q_H)

The habitat sensitivity rate, q_h, is the proportion of habitat impacted by one pass of the fishing net. Organisms considered as indicators of habitat sensitivity range from relatively small and flexible (soft corals) to larger, more erect organisms (sea whips). Vulnerability of the organisms varies greatly depending on their physical characteristics and the characteristics of the trawl gear. The vulnerability may be difficult to determine. Certain features of the gear may make the gear more damaging to one type of organism than to another type. For biostructure sensitivity to bottom trawl gear, two values of q_H, 0.10 for less sensitive, and 0.25 for more sensitive, are proposed as plausible.

Habitat Recovery Rate (ρ)

Recovery rate, ρ , reflects the rate at which impacted habitat changes back into unimpacted habitat, H. In the absence of further impacts, impacted habitat would decrease exponentially with all habitat was in H the unimpacted condition. The recovery time, R, can be thought of as the average amount of time the impacted habitat stays in the impacted state, which would equal 1/ ρ in the absence of further impacts.

Little is known about the recovery rate of various benthic organisms that provide biostructure in waters off Alaska. The recovery rate as modeled includes any recruitment required to initiate recovery and the growth necessary to reach a size that can to provide habitat function. Recovery times as much as 15 (=1/ρ) years are within a plausible range. For this analysis, two biostructure recovery rates are used to cover a plausible range of impact. Scenario 1 is where $\rho = 0.5$ the 2-year or rapid recovery, and Scenario 2 is where $\rho = .0667$, the 15-year or long recovery. Table 4.1-25 shows the corresponding impact given levels of fishing intensities. For example, for $f = 0.25$, where the bottom area is swept once every four years, for $\rho = 0.50$, when habitat recovers in 2 years, and for a sensitivity rate $q_H = 0.10$, where one-tenth of the organisms are removed per sweep of the net, the long-term impact level, E, would be 0.049. That is, the habitat would be reduced slightly to 95.1 percent (H_{eq}) of its unfished level. If recovery rate $\rho = 0.067$, where habitat recovers in 15 years, and sensitivity $q_H = 0.25$, where one-fourth of the organisms are removed per sweep of the net, the impact level would be 0.499, or 50.1 percent of its unfished level. This demonstrates that as f increases, impact level also increases, and the equilibrium level of habitat decreases.

Fishing Effort or Intensity (*f*)

Bottom trawl fishing effort has been estimated for each 5 kilometer (km) square block in the BSAI and GOA regions by Rose and Jorgenson (2002). Fishing intensity of a block is the fishing effort per year measured in area swept.High quality fishing effort data are available from the groundfish observer program. Individual sets were tallied for 5 x 5 km blocks for the years 1998 to 2002. This 5-year period was selected to represent the current level of fishing effects. Reported effort or duration for trawls was converted into swept areas. Trawl durations were multiplied by speed, trawl width, and proportion of effort on the bottom. Width and speed were estimated using a survey of trawlers on gear usage and from information collected by observers. The estimate for the proportion of pelagic trawl effort contacting the seafloor considered both the amount of time in which any part of the trawl contacted the seafloor and the width of trawl contact with the seafloor during different periods of the fishery (e.g., day/night, A and B seasons). Information for this estimate was provided by fishing organizations. As the vulnerability of pelagic trawls to damage precludes their operation on rough and hard substrates, bottom contact was set at zero for the hard bottom habitats of the GOA and Aleutians Islands.

Habitat Impact (*E*)

Impact is a function of sensitivity, recovery rate, and fishing intensity. For the given values of sensitivity q_h, recovery rate ρ, and bottom trawl fishing intensity *f* estimated for each 5 x 5 km block, habitat impact, $E_i = I_i/(I_i + \rho S_i)$, can be calculated for the 5 x 5 km block represented by the *I* parameter. Larger values of *E* equate with more impacts. Results for a region can be presented in a single value as a mean impact, as frequency distribution of impacts for each block, and as the geographic distribution of the impacts.

A draft report by Rose (2002) describes a proposed approach to quantifying impacts using the function = $(\sum E_i \cdot \text{Area}_i) / (\sum \text{Area}_i)$ summed over all area in waters less than 1,000 meters (m) deep (i.e, fishable EEZ waters). This is a single-valued metric which provides for simplified comparisons and evaluations. Ideally, any area summations would be weighted by habitat quantity and value as well, but such information is currently unknown and is set at 1.

In the analysis for this Programmatic SEIS, rather than summing the estimated impact block by block, the fishing intensity for each block is tabulated by intensity intervals, as shown in Table 4.1-26. For example, in the Bering Sea, 1,003 blocks were fished at an intensity level between 0.25 and 0.50, 822 blocks watershed at an intensity level between 0.50 and 1.00, and so forth. This information can be used to estimate the mean relative impact level for all the fished blocks, or for all fishable blocks (<1,000 m). This is approximated here by summing the frequency weighted midpoint impact levels and dividing by the number of fished blocks or number of fishable blocks. For example, for ρ=0.50 and q_H=0.10, the impact level for f=0.25 is 0.049, and for f = 0.50 is 0.095, with a midpoint of 0.072. The frequency weight of the interval 0.25 to 0.50 is 1,003. The interval midpoint impact levels are weighted and summed and divided for the Bering Sea by either 7,121 (number of fished blocks) or 31,995 (number of blocks <1,000 m in depth). For the more slow growing and more sensitive parameter scenario, the mean impact of fished areas is 0.419 and 0.093 for all fishable blocks.

This approximation should produce mean impact levels similar to the more exact computation method demonstrated in a report by Rose (2002). Ideally, any area summations would be weighted by habitat quantity and value as well, but such information is currently unknown and neither computation takes into account differences in the unfished level of biostructure habitat or habitat suitability that probably exist. This is a single-valued metric, which provides for simplified comparisons and evaluations. If all habitat over the fishable EEZ is of equal value to the productivity of the fisheries, then the simple mean impact estimates are indicative of the baseline fishing impacts. However, when summed over such broad categories of habitat, the mean impact value may not reflect effects if impacts are concentrated on specific habitat types, because not all habitat may be of equal value to stock productivity. Comparing impact expressed as a single value presumes that the value of different levels of impacts is additive. That is, two units of habitat each impacted to H_{eq} = 0.75 (E = 0.25) are equivalent to two units of habitat, one heavily impacted to H_{eq}=0.50 (E = 0.50) and one unimpacted at H_{eq} = 1.0 (E = 0.0). Thus, the average impacts are equal in both cases, but the actual effect on the ecosystem may not be equivalent. One could argue that all else being equal, the latter case provides a wider range of habitat type and greater diversity over the same amount of habitat and is preferred over a uniform distribution of impact. In contrast, if H_{eq} only needs to be greater than 0.5 to be effective EFH, the former case would be preferred. Whatever the case may be, comparison of the frequency distribution provides increased discernment of potential impact. Thus, the distribution of the impacts needs to be considered.

Mean impact levels were assessed in conjunction with the distribution information to further evaluate the baseline. While the mean impact values could be considered to indicate minor impacts, the distribution information shows that for the Bering Sea, for example, 552 + 277 = 829 blocks, or more than 8,000 sqare miles, are fished at an intensity of f = 1.00 or greater (Table 4.1-26). A map of the fishing distribution (Figure 4.1-10) shows that the heavily fished blocks are concentrated in a few large geographically extensive areas that are uninterrupted by any current fishing closures that might provide protection to or diversity in impact levels. The impact model estimates that those areas could have an impact level to bioshelter organisms of 18.1 percent or greater for the fast recovery rate parameter scenario, or as much as 82.8 percent for the slow

recovery rate/more sensitive scenario. Concern for areas where such potential impact could be occurring is a major consideration in the evaluation of the baseline and comparison of the alternatives.

General results using the habitat model are used qualitatively to evaluate the closure strategies of the alternatives. The rates of relative change of catch and impact can be examined by combining the habitat impact model with standard fishery catch models. In general, closing large amounts of heavily fished areas may not result in significant reduction in net habitat impact, as large amounts of fishing effort are displaced. This results in increased impact levels in previously less heavily fished area. Such a large change in the system has high potential for unforeseen consequences. A strategy of closing only lightly fished habitat reduces further impact in those areas while displacing only moderate amounts of effort to heavier fished areas. An increase of effort in already heavily fished habitat increases habitat impact relatively less than an increase in lightly fished habitat. Such a strategy, however, does not address potential ongoing impacts in heavily fished areas. A strategy of closing only small proportions of heavily fished habitat and larger proportions of lightly fished areas can achieve similar or greater reductions in impact with only moderate increases in effort in the remaining open areas. With closures positioned appropriately, this strategy can protect a cross-section of habitat types and address the potential impacts of heavily fished habitat while minimizing economic effects and the chances of unforeseen consequences.

4.1.7 The Sector Model–An Adaptation of the Multi-Species Model To Estimate Socioeconomic Effects

The socioeconomic impacts of the alternatives have been estimated using an extension of the multi-species model based on the harvesting and processing sectors and regions described in Sections 3.9 and 3.9.3. For the remainder of this discussion, the socioeconomic model extension is referred to as the sector model. The sector model applies 2001 harvest and processing proportions to the multi-species management (Ianelli) model output related to species catch by gear and subarea in order to estimate the distribution of catch and processing amounts among sectors and regions that rely on the groundfish fishery. A schematic representation of the linkages between the two models is shown below.

The sector model entails the following three-step process:

1. Estimate total catch and deliveries to processors.

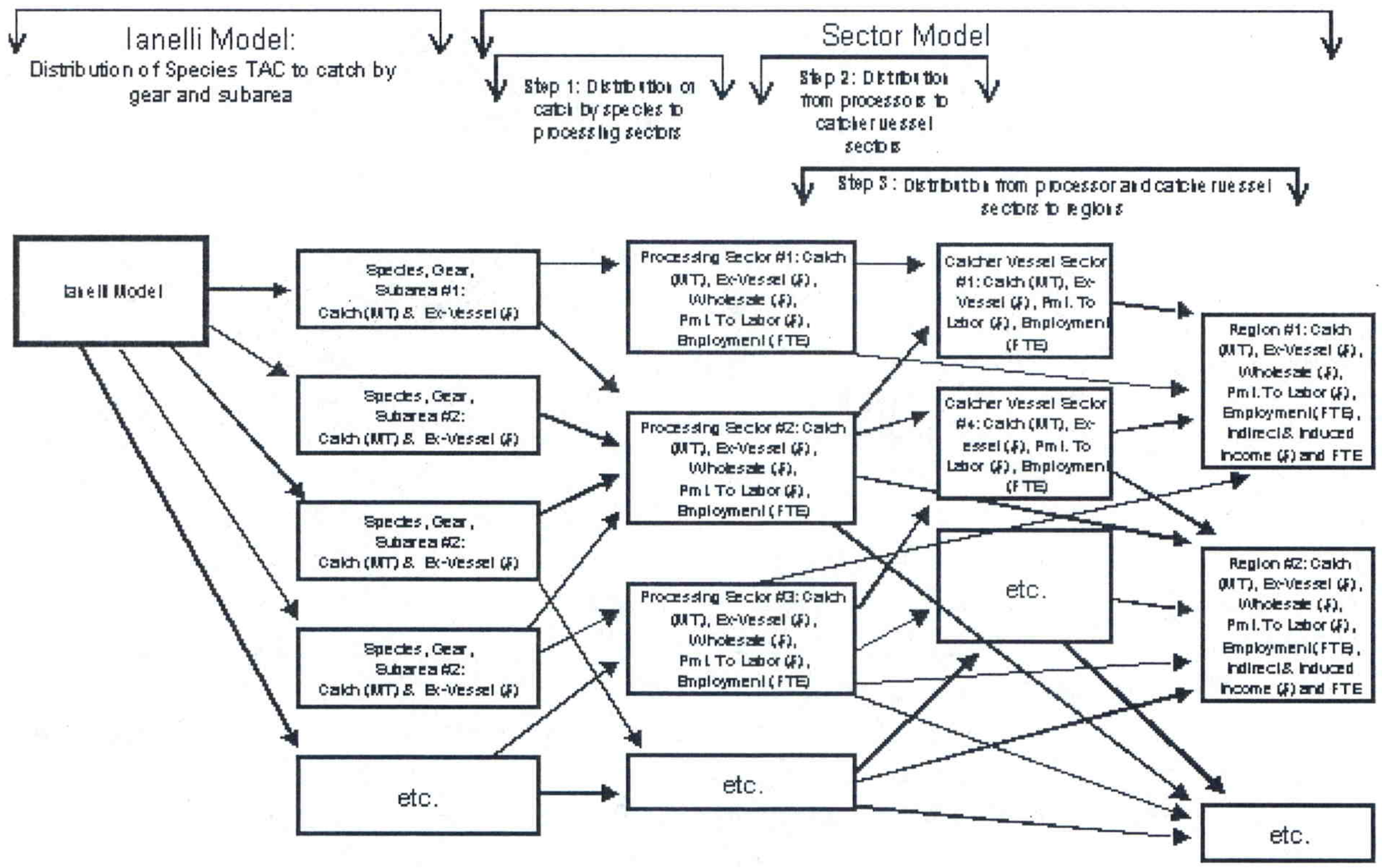
2. Proportion out deliveries to specific catcher vessel sectors.

3. Distribute catches and processing amounts among the various regions where processors are located or vessel owners reside.

In each step of the sector model, the catch of each species by gear and subarea gets distributed to successive sectors based on the comparative baseline distribution in 2001.

The steps of the sector model can best be illustrated by providing a specific example. The multi-species management (Ianelli) model estimates that 1,472,600 mt of pollock will be harvested from the Bering Sea with trawl gear in 2003 under FMP 1. In step 1 of the sector model, this pollock is distributed to each processor sector according to the proportion of the total 2001 Bering Sea trawl pollock catch that the individual sector processed, including discards. In addition to total catch, the model uses 2001 information

on each sector's retention percentage, wholesale value per round ton, payments to labor per dollar of wholesale product value, and full time equivalent (FTE) employment. These numbers are taken from the comparative baseline data presented in Section 3.9.9. Table 4.1-27 shows the 2001 conditions and how they are applied to generate the 2003 sector estimates for FMP 1. The results from Step 1 of the sector model are used to estimate the direct economic impacts of the alternative FMP bookends on the various processing sectors.



As shown in the upper portion of the table, surimi trawl catcher processors caught 35.3 percent of the 2001 pollock trawl harvest from the Bering Sea and retained 99.8 percent of their catch. In the lower portion of the table, 35.3 percent of the 1,472,600 mt Bering Sea pollock trawl total under FMP 1 in 2003 is assigned to the surimi trawl catcher processor sector. The table also shows that 99.8 percent of the 519.3 mt of groundfish caught was retained. Assuming a wholesale product price of $604.4 per ton, the 2003 estimated wholesale product value for surimi trawl catcher processors is $313.8 million, with an estimated 35 percent ($109 million) of that be paid to labor. Employment generated by this sector is estimated to be 1342.8 FTEs, or 4.3 FTEs per million dollars of wholesale product value. A similar process is used to estimate the economic effects on other processing sectors.

Step 2 of the sector model distributes each processing sector's total retained catch amount back to the catcher vessels that delivered it, based on the proportion of each processing sector's deliveries from catcher vessel sectors in 2001. The analysis developed for each species, gear, and subarea, a processor sector/catcher vessel sector distribution matrix based on 2001 deliveries. The matrix for the Bering Sea trawl pollock sector is shown in Table 4.1-28. The table includes deliveries of catcher vessels to surimi and fillet catcher processors, inshore processors, and motherships. Although catcher vessels delivered only a relatively small amount of

fish to surimi and fillet trawl catcher processors, they provided all the fish processed by other processing sectors. For example, the row for Bering Sea pollock shore plants indicates that 61.5 percent of their Bering Sea trawl pollock was delivered by Bering Sea pollock trawl catcher vessels greater than or equal to 125 ft, while Bering Sea pollock trawl catcher vessels 60 ft to 125 ft in length delivered 34.8 percent of the pollock catch. The remaining 3.6 percent was delivered by diversified AFA-eligible trawl catcher vessels greater than or equal to 60 ft and non-AFA trawl catcher vessels greater than or equal to 60 ft. The various catcher vessel sectors are defined and discussed in detail in Section 3.9.2.

The percentages, like those in Table 4.1-28, are multiplied by the total catch for the species gear and subarea for each processor to generate the total retained catch assigned to each catcher vessel sector for the FMP bookend and year. Ex-vessel prices and payments to labor and employment factors are applied to retained catches to generate the remaining catcher vessel sector indicators. Table 4.1-29 illustrates this process with numbers for the Bering Sea trawl pollock sector for FMP 1 in year 2003.

The third step of the sector model translates sector level activities to regional activities. This step is complex because the various sectors interact with regions in different ways, as described below:

- **Shore-Based Processors:** The sector model assumes that shore-based processors are closely related to the regions in which they are located. In fact, the shore-based processors are designated according to their associated region. Two exceptions are the Bering Sea Pollock Shore Plants, which are assigned to the Alaska Peninsula/Aleutian Islands region, and the Other States Shore Plants, which are assigned to the Washington inland waters region (most are located in Bellingham, Washington). The sector model assumes that ex-vessel values attributed to shore-based processors are directly linked to the region in which they are located through fish taxes. Further, the sector model assumes that all labor payments and employment generated by shore-based processors accrue within the region in which they are located.[1] This method of assigning employment to regions is similar to that used by state and federal agencies. Insufficient information exists to provide a more accurate account of regional employment patterns in the groundfish fisheries. Finally, the sector model assumes that the expenditures of shore-based processors for deliveries of raw fish and other supplies, as well as the expenditures of their employees, have indirect and induced impacts within the region in which they are located.[2]

[1] The method of assigning employment to regions used in this analysis does not attempt to account for the formal or legal residency of workers in shore-based processors. For example, the labor force of many of the shore plants in Alaska, especially those in the Alaska Peninsula and Aleutian Islands region (defined in Section 3.9.2.4), have been traditionally dominated by persons considered non-residents or relatively short-term residents of Alaska communities or the state. In part, residency is a matter of definition, as community population count varies by information source. U.S. Census methodology, for instance, counts every person present at the time of enumeration as part of the official population of the community, with very few exceptions. Additional information on workforce demographics and the role that transient processing workers play in the groundfish fishing industry and communities can be found in Section 3.9.6.

[2] Another shortcoming of the sector model is that it is unable to track expenditures of processors and catcher vessels in other regions. For example, many of the shore-based processing plants have headquarter offices in Seattle, and clearly some of their expenditures are made in the location of their headquarters. Further, because many of the employees of shore-based plants are seasonal, they are likely to spend most of their earnings in their hometowns.

- **At-Sea Processors (Catcher Processors, Motherships, and Floating Processors):** The sector model assumes that an at-sea processor generates most of its regional impacts in the region represented by the vessel owner's address as listed in Commercial Fisheries Entry Commission vessel registration files or NOAA Fisheries Federal permit data. Typically, the location of the corporation that coordinates the operations of the vessel is listed. Consequently, the model assumes that crewmembers on a catcher processor or other at-sea processor are hired from the same region in which the vessel's operations are coordinated.[3] Although this method of assigning employment to regions is similar to that used by state and federal agencies, it is recognized that this is a simplification, as vessels (and corporations) may have complex ownership structures that influence various operational parameters, including point-of-hire employment decisions.[4] As noted above, insufficient information exists to provide a more accurate account of regional employment patterns in the groundfish fisheries. Other economic impacts, such as those resulting from purchases of equipment and supplies, are also assumed to accrue to the vessel owner's region.

- **Catcher Vessels:** In order to be consistent with the way in which at-sea processing employment is assigned, catcher vessel employment is assigned to the region represented by the vessel owner's address as listed in Commercial Fisheries Entry Commission vessel registration files or NOAA Fisheries Federal permit data.[5] catcher vessels affect regions by making deliveries to processors and providing earnings for their returning owners and crew to spend in the region. When these vessels make deliveries to processors located outside of the region, they bring their outside earnings into their home region when they return. However, when catcher vessels make deliveries to local processors, their earnings are already counted as expenditures by the local processors. Therefore, it is important to track not only the catcher vessels' home regions, but also the locations where they delivered fish. The sector model assumes that all vessel owner and crew income contributes to the regional economy, but, to avoid double counting, only the income from landings made outside the region is used to calculate indirect and induced income and employment.

A matrix showing the home regions of vessels participating in the pollock trawl fishery in 2001 in shown in Table 4.1-30. Similar matrices were developed for each species, gear, and area combination.

Multiplying the numbers in the regional matrix in Table 4.1-30 by the catches by sector (Table 4.1-27 for at-sea processors and Table 4.1-29 for catcher vessels) yields the regional apportionment of Bering Sea trawl

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[3] The method of assigning employment to regions used in this analysis does not attempt to account for the formal or legal residency of workers in the at-sea processing sector.

[4] As one example of this complexity, the western Alaska CDQ program has created many seasonal job opportunities for residents of eligible Alaska communities aboard catcher processors as a result of CDQ investment in this sector, among other factors. Beyond employment considerations, additional information regarding the importance of CDQ program-related investments and industry partnerships in increasing the participation of Alaska residents in the groundfish fisheries, especially those in Alaska Native communities, is provided in Section 3.9.4.

[5] The method of assigning employment to regions used in this analysis does not attempt to account for the formal or legal residency of workers aboard catcher vessels. For example, some of the catcher vessels owned by residents of the Washington Inland Waters Region (WAIW) region (defined in Section 3.9.2.4) that frequently berth in Alaska ports may hire residents of those ports. Moreover, as in the case of the at-sea processing sector, complex corporate ownership structures may influence vessel operational patterns, including crew employment decisions.

pollock catches for 2003 from FMP 1 (as shown in Table 4.1-31). A similar process is used to assign catches of other species, gears, and areas to regions for other years and for other FMP bookends.

The next step in estimating regional effects of catcher vessels involves distinguishing in-region deliveries and extra-regional deliveries. In-region deliveries are defined as deliveries to processing facilities assigned to the same region to which the catcher vessel is affiliated. For example, when a vessel owned by a resident of Kodiak makes a delivery to a Kodiak shore plant, it is considered an in-region delivery. When that same boat makes a delivery to an Alaska Peninsula/Aleutian Islands shore plant, it is considered an extra-regional delivery. It should be noted that at-sea deliveries are considered in-region ,if the both the owner of the catcher vessel and owner of the at-sea processor are from the same region. As indicated earlier, the regional effect of catcher vessels making an in-region delivery are counted as part of the regional shore-based processor effects, while the regional effects of extra-regional deliveries are assigned to the catcher vessels. Table 4.1-32 shows the 2003 value of in-regional and extra-regional deliveries of Bering Sea trawl pollock by the catcher vessel sectors for FMP 1.

The sector model's final step calculates and assigns income and employment multipliers for each region. The multipliers relate total output in dollars from the fishing sector in a region to the additional indirect and induced income and employment that are generated. Part of this additional income and employment occurs in the businesses whose goods and services are used as inputs in the groundfish fisheries, such as fuel suppliers, chandlers, gear manufacturers, boatyards, and insurance brokers. These firms are commonly referred to collectively as the support service sector of the fisheries. Moreover, people earning incomes directly or indirectly from the fisheries make expenditures within the economy as well, generating additional jobs and income. These indirect and induced economic benefits can be substantial, especially for regions such as the WAIN region. The multipliers used in this analysis are estimated with IMPLAN Version 2.[6] The IMPLAN software was used to create an input-output model for each region considered in the analysis. The input-output model is a mathematical representation of the inter-industry/institution transactions that occur within a defined economic region. The model traces how many times a dollar is re-spent within the regional economy before leaving the region, and the economic impact of each round of spending. The economic base concept was used to determine the level of aggregation of the more than 200 economic sectors that have backward linkages to the fishing sector in the regions considered. The multipliers for these economic base sectors or aggregated sectors were generated from IMPLAN, and were used to determine the additional income and employment effects, or secondary effects, that the fishing sector contributes to each region. Table 4.1-33 shows the regional multipliers used in the analysis.

It is important to note that the sector model does not directly estimate inter-regional linkages. For example, the model does not specifically include income and employment resulting from expenditures of at-sea processors in regions outside of a vessel owner's region. While it is recognized that there are inter-regional effects, the data necessary to reasonably estimate those effects are not available. It is also important to note that the lack of inter-regional effects is offset to some extent by the assumption that all of the employment and income effects of a shore-based processor occur within the region in which the processor is located.

An example of the tables used in the regional effects assessment is provided in Table 4.1-34. The example shows the effects of the Bering Sea pollock trawl fishery on the Alaska Peninsula/Aleutian Islands region for FMP 1 and 2003.

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[6]1999 IMPLAN baseline data, which are the most current available, were used to estimate the multipliers.

4.2 Introduction of Analytical Framework – Example Fishery Management Plans

Four policy alternatives and a preferred alternative are analyzed in this document. In order to provide sufficient detail to the analysis of the policies, each alternative is accompanied by, and associated with, a set of example FMPs. A description of the framework concept, followed by a summary of each alternative policy and their associated FMPs, is provided below.

4.2.1 Concept of the Analytical Framework

Each alternative is composed of three elements: a management approach statement that describes the goals, rationale, and assumptions behind the alternative; a set of management objectives that complement and further refine the goals set forth in the management approach; and, except for Alternative 1 (status quo), a pair of example FMP bookends that illustrate and frame the range of implementing management measures for that alternative. The management approach statement and objectives serve to define the direction the NPFMC and NOAA Fisheries wish to take in the managing the fisheries. The example FMP bookends serve two purposes: first, they provide an additional level of analytical detail that will facilitate the comparison of the physical, biological, and socioeconomic effects of the alternatives and the status quo; second, they provide the public with an illustration of the types of management measures the NPFMC and NOAA Fisheries envision using to achieve the goals of the alternative. The preferred alternative identified in this document includes a policy statement accompanied by a set of management objectives and a set of example FMP bookends that illustrates a range of management actions for that policy. This FMP framework structure communicates to the public how NPFMC and NOAA Fisheries intend to pursue their policy objectives in the future. By providing a range of potential management measures (as illustrated by the example FMP bookends as part of the preferred alternative), management flexibility is maintained under the MSA to adaptively manage the fishery through FMP amendments.

4.2.2 Description of the Example Fishery Management Plan Frameworks

Alternative 1 – Continue Under the Current Risk-Averse Management Policy

Under Alternative 1, the groundfish fisheries would continue to be managed based upon the present risk-averse policy. Alternative 1(a) represents the policy language currently stated in the FMPs, dating from 1979 and 1985 for the BSAI and GOA FMPs, respectively (see Section 2.6.1 for the full text of the alternative). These policies, based on the best scientific information available, avoid irreversible or long-term adverse effects on fishery resources and the marine environment, while at the same time providing for optimum yield.

Alternative 1(b) is a substitute for the written policy language in the current FMPs that would include objectives that specifically address the variety of concerns that are balanced in current management considerations (see Section 2.6.2 for the full text of the alternative). Alternative 1(b) encapsulates a risk-averse conservation and management program that is based on a conservative harvest strategy. This policy assumes that fishing does result in some adverse impacts to the environment, and as these impacts become known, mitigation measures will be developed and appropriate FMP amendments will be implemented.

FMP 1 (Current BSAI and GOA Groundfish FMPs)

Alternative 1(a) and 1(b) policies are both represented by FMP 1, which is the current fisheries management program for the BSAI and the GOA and incorporates management measures approved by the NPFMC through the June 2002 meeting. FMP 1 is described in full in Table 4.2-1.

In the current FMPs, the TAC is determined annually based on a conservative harvest strategy that calculates the OFL and the ABC for each managed stock or stock complex. The current FMPs specify the OFL and maximum ABC (max_{ABC}) by means of a six-tier system, wherein the amount and quality of information available for a given stock or stock complex determine the formula that is used to define F_{OFL} and max F_{ABC} (Tiers 1-5) or OFL and max_{ABC} directly (Tier 6). Most stocks are currently managed under Tier 3, where max F_{ABC} equals $F_{40\%}$ if biomass is above $F_{40\%}$. Precautionary adjustments are made, including decreasing F_{OFL} and F_{ABC} linearly with biomass whenever biomass falls below a tier-specific reference level, but only Tier 1 stocks include an uncertainty variation in max_{ABC}. The status of each stock in Tiers 1 through 3 is also examined annually with respect to the MSST, as defined in the National Standard Guidelines.

OY is specified in the current FMPs as a range that is aggregated across all stocks and does not vary with biomass. The current FMPs require the sum of the individual groundfish TACs to fall within the OY range. In the BSAI, the high end of the range, 2 million mt, acts as a cap on the TACs, as the aggregated ABCs regularly exceed this limit. In practice, although it is not required in the current FMPs, TACs are never set higher than the corresponding ABCs. Taking into account the ecosystem considerations of the food web, the current FMPs also prohibit directed fishing for forage species.

Through amendments over the last twenty years, the current FMPs have built up a network of spatial/temporal closed areas intended to protect resources of concern, as well as to minimize gear conflicts. In the BSAI, various areas around the Pribilof Islands and in Bristol Bay are closed year-round to trawling in order to protect red and blue king crab habitat, and there are chinook and chum salmon areas that are closed seasonally. Also in the BSAI, waters within 12 nautical miles (nm) of the Walrus Islands are closed to groundfish fishing to minimize disturbance near walrus haulouts. In the BSAI and the GOA, areas within 3 nm of Steller sea lion rookeries are permanently closed to fishing. Additionally, Steller sea lion protection measures impose trawl prohibitions within 10 to 20 nm of all rookeries and haulouts and prohibit fishing in Seguam Pass. In the GOA, trawling is prohibited in southeast Alaska west of 140°W longitude. Also, a 2.5 square nm (nm^2) area designated as the Sitka Pinnacles Marine Reserve in the GOA is closed to groundfish fishing to protect habitat for rockfish and lingcod (Figure 4.2-1).

The current BSAI FMP prohibits directed fishing for pollock with non-pelagic trawl gear. There is no similar restriction on pollock trawling in the current GOA FMP. Directed fishing for sailfish with longline pot gear is prohibited in the GOA. Non-pelagic trawling is prohibited in the Bristol Bay Red King Crab Savings Area in the BSAI and in the Cook Inlet in the GOA. Additionally, various areas around Kodiak Island are closed to non-pelagic trawling either year-round or seasonally to protect crab stocks (Figure 4.2-1; specific details on the FMP 1 map illustration are provided in Section 4.2.3).

Groundfish fisheries in the BSAI and GOA are required to discard any incidental catch of halibut, salmon, crab, herring, or Steelhead trout, known collectively as prohibited species. The FMPs currently set PSC limits on many of these species, with penalties ranging from closure of a particular zone or of the whole management area to closures of a directed fishery or fisheries for a specified season or for the remainder of

the year. In the BSAI FMP, stairstep-based limits (i.e. the catch limit varies based on stock abundance) for trawl bycatch within specified zones are set for red king crab and C. bairdi crab. The BSAI FMP also specifies an absolute trawl catch limit for chinook salmon and "other salmon" within specified zones. Once the apportioned PSC limit for a trawl fishery is reached within a zone, the fishery is prohibited from fishing within that zone. The BSAI FMP specifies a trawl catch limit for herring in the BSAI at one percent of annual biomass. Catch limits on C. opilio crab and halibut bycatch in the BSAI are established in regulation. The C. opilio catch limit applies to a specified zone and is based on an adjusted percentage of biomass that must fall within a certain range. The halibut catch limit is a BSAI-wide limit measured in mt and is based on halibut mortality. In the GOA FMP, catch limits on halibut bycatch are authorized and set by the NPFMC as part of the annual procedure for setting groundfish harvest levels. There are no other PSC limits set in the GOA.

Other bycatch reduction measures are required under FMP 1. The Improved Retention/Improved Utilization (IR/IU) program requires that vessels fishing for groundfish fully retain all pollock and Pacific cod fit for human consumption, as well as fully utilizing the two species by inshore processors. A minimum utilization standard of 15 percent is set for all at-sea processors. The NPFMC is also adopting a policy to require full retention of demersal shelf rockfish by hook-and-line and jig vessels in the Southeast Outside District of the GOA. A Vessel Incentive Program (VIP) encourages bycatch reduction by setting bycatch reduction standards biannually. Vessels that fail to meet these standards can be penalized. Inseason bycatch management measures establish fishing seasons for bycatch management and give the NOAA Fisheries, Alaska Regional Administrator the authority to close areas with high bycatch.

The Reasonable and Prudent Alternative (RPA) measures adopted from the most recent USFWS biological opinion on the short-tailed albatross stipulate the use of certain seabird avoidance measures and require that the take of more than four short-tailed albatross within 2 years trigger consultation with the USFWS and the potential closure of fisheries. To further reduce the possibility of the fisheries' take of albatross, the NPFMC in 2001 required all longline vessels to adopt more stringent seabird avoidance methods.

A Licence Limitation Program (LLP) for groundfish vessels over 32 ft in length (with certain jig gear exceptions) and a moratorium on entry into the groundfish fisheries is in place for the BSAI and the GOA. An IFQ program is in place for sablefish in the BSAI and GOA, which includes provisions for community purchase of quota share. In the BSAI, the directed fishery for pollock is organized into cooperatives as authorized under the AFA. A multi-species CDQ program apportions 7.5 to 10 percent of all BSAI groundfish quota to 65 eligible western Alaska communities.

FMP 1 monitors the groundfish fishing effort through federal and state reporting requirements and through the use of the North Pacific Groundfish Observer Program. All vessels between 60 ft and 125 ft in length are required by regulation to have an observer on board 30 percent of the time; for vessels over 125 ft in length this increases to 100 percent. For AFA and CDQ catcher boats greater than 60 ft in length, one observer must be on board at all times, and for catcher processors and motherships, two observers must be on board at all times. The program also requires observers at inshore processing plants. An additional monitoring tool is the reporting requirements for BSAI and GOA vessels to submit daily or weekly logbooks that include information on the composition of catch and the locations of the hauls. The ADF&G also collects data from fish tickets at the point that catch is sold. Mandatory Vessel Monitoring Systems (VMS) verify vessel locations for all directed Atka mackerel, pollock, and Pacific cod fishing.

Alternative 2 – Adopt a More Aggressive Harvest Management Policy

Alternative 2 would maximize biological and economic yield from the resource while still preventing overfishing of the groundfish stocks. Such a management approach would be based on the best scientific information available, would take into account individual stock and ecosystem variability, and would continue to work with other agencies in protecting threatened and endangered species. A more aggressive harvest strategy would be implemented based upon the concept that the present policy is overly conservative and that larger harvests can be taken without overfishing the target groundfish stocks. This policy assumes that fishing at the recommended levels would have no adverse impact on the environment, except in specific cases that are known and mitigated. For the full text of the alternative, see Section 2.6.3.

Example FMP 2.1

Example FMP 2.1 illustrates a more aggressive harvest strategy than Alternative 1 by removing many of the existing constraints from the fisheries. Example FMP 2.1 is described in full in Table 4.2-1. As the policy is based on an assumption that the impacts of fishing on the environment are generally known and mitigated, the precautions currently built into the existing TAC-setting process would be alleviated. The buffer between the ABC level and the OFL would be removed, and the maximum OY for the groundfish stocks in the BSAI would be released from its 2 million mt cap and allowed to float as the sum of the OFLs for the BSAI groundfish stocks. Additionally, example FMP 2.1 removes the precautionary element included in the current FMPs that decreases F_{ABC} linearly with biomass when the biomass falls below a specific reference level.

Example FMP 2.1 would also remove physical constraints from the fisheries by repealing the various closure areas currently in place. The fishery would be returned to an open-access scenario, where time and area closures, gear restrictions, and prohibited species catch restrictions are repealed. The potential impact of the groundfish fisheries on Steller sea lions, however, means that the current mitigating suite of protection measures that constrain fishing around rookeries and haulouts and protect Steller sea lion prey species (pollock, Pacific cod and Atka mackerel) when at low biomass levels would remain in place (Figures 4.2-2 and 4.6-1; specific details on the example FMP 2.1 map are provided in Section 4.2.3). This is required by the ESA to avoid determinations of jeopardy and adverse modification to Steller sea lions. The same applies to the impact of groundfish fishing on short-tailed albatross, where the current take limits would remain in effect.

The federally-mandated effort limitation program for the directed BSAI pollock fishery, enacted under the AFA, would remain in place, with its accompanying CDQ allocation, but all other effort limitation programs (such as the sailfish IFQ program and the multi-species CDQ program) would be repealed. Reporting requirements would remain in place, but the observer program, except as federally mandated by the AFA, would be repealed, as would VMS requirements.

Example FMP 2.2

A more moderate illustration of Alternative 2, example FMP 2.2, also represents a more aggressive harvest strategy than Alternative 1. Example FMP 2.2 is described in full in Table 4.2-1. In this case, the mechanisms for setting ABC and TAC remain the same as in the current FMPs (see FMP 1 for further detail), but the existing regulatory capped maximum OY of 2 million mt in the BSAI would be removed in favor of a maximum OY equaling the sum of individual groundfish ABCs in the BSAI. Additionally, bycatch reduction

incentives and bycatch restrictions would be repealed, other than those related to PSC limits or IR/IU. Under the assumption that fishing does not have an impact on the environment other than what is generally known and mitigated, the more stringent seabird avoidance measures enacted in 2001 would be repealed, leaving only the mitigation measures recommended by USFWS to avoid jeopardy or adverse modification for short-tailed albatross. Closure areas in example FMP 2.2 are the same as those in FMP 1 (Figure 4.2-3; specific details on the example FMP 2.2 map are provided in Section 4.2.3).

Alternative 3– Adopt a More Precautionary Management Policy

Alternative 3 would seek to increase the existing precautionary management measures through community or rights-based management, ecosystem-based management principles, and, where appropriate and practicable, increased habitat protection and additional bycatch constraints. Under this approach, additional conservation and management measures would be implemented as necessary to respond to social, economic or conservation needs, or if scientific evidence indicates that the fishery was negatively impacting the environment. This policy recognizes the need to balance many competing uses of marine resources and different social and economic goals for fishery management. For the full text of the alternative, see Section 2.6.4.

Example FMP 3.1

Example FMP 3.1 illustrates a management approach that accelerates precautionary management measures by increasing conservation-oriented constraints on the fisheries where necessary, formalizing precautionary practices in the FMPs, and initiating scientific review of existing practices as a precursor to the decision of how to best incorporate adequate precautions. Example FMP 3.1 is described in full in Table 4.2 1.

Example FMP 3.1 implements changes to the TAC-setting process following a comprehensive review. Precautionary measures such as setting TAC less than or equal to the ABC and specifying MSSTs for Tiers 1 through 3 in accordance with National Standard Guidelines, would be formalized in the FMP. Sharks and skates would be removed from the Other Species management category and given their own TACs, and criteria to do the same for other target stocks would be developed. Efforts would be accelerated to develop ecosystem indicators for setting TAC limits, as per ecosystem management principles,.

In order to balance the needs of social and economic stability with habitat protection and resource conservation, a review would be conducted of the existing closure areas in the BSAI and the GOA (for closure areas under FMP 3.1, see Figure 4.2-4 and Section 4.2.3). The closure areas would be evaluated against a Marine Protected Area (MPA) methodology, which would be developed as part of this alternative. The NPFMC and NOAA Fisheries would also seek to initiate joint consultation and research with USFWS to develop fishing methods that reduce incidental take of threatened and endangered species. To mitigate any adverse impacts of fisheries management decisions on fishing communities, and to comply with other national directives, formal procedures would be implemented to encourage increased participation of Alaska Natives in fishery management.

Example FMP 3.1 recognizes that the anticipated community or rights-based management programs may ultimately address bycatch reduction objectives (a review of bycatch rates under current programs has been initiated) but, a moderate reduction of PSC limits will be initiated as an intermediary step. Additionally, PSC limits for crab, herring, and salmon would be authorized in the GOA, in addition to the halibut PSC limits

authorized under the current GOA FMP. Effective monitoring and timely reaction to change in the environment and the fisheries would be enhanced through improvements in the observer program and third party verification of economic data.

Example FMP 3.2

Example FMP 3.2 implements the increase of existing precautionary measures on a more rapid timeline than example FMP bookend 3.1. Example FMP 3.2 is described in full in Table 4.2-1. Rather than reviewing existing practices prior to incorporating increased precautions, this bookend implements changes to many aspects of the FMPs concurrently with the initiation of scientific research efforts necessary to bring management measures in line with a precautionary policy.

Example FMP 3.2 significantly accelerates precautionary management by incorporating an uncertainty correction into the estimation of ABC for all species. Additionally, OY would be specified separately for each stock or stock complex rather than for the groundfish complex as a whole (i.e., OY would be set as a formula rather than as a range, eliminating the BSAI 2 million mt OY cap), and would be set equal to the respective stock or stock complex's TAC. The current precautionary practice of setting TAC less than or equal to ABC would be formalized in the FMP. Example FMP 3.2 would also incorporate stock-specific biological reference points in the tier system where scientifically justifiable. This could result in Tier 3 rockfish stocks, for example, being capped at $F_{60\%}$ rather than $F_{40\%}$. In implementing this bookend, criteria would be developed for specifying MSSTs for Tiers 4 through 6, along with a list of priority candidate stocks; and the development of criteria for moving stocks from the Other Species and Nonspecified Species management categories would minimally result in sharks and skates being given their own TACs.

Example FMP 3.2 also reexamines the existing closure system in the BSAI and the GOA. The bookend sets a guideline of 0 to 20 percent of the EEZ (3 to 200 nm) to be closed as an MPA, of which no more than 5 percent should be completely closed to commercial fishing as a designated No-Take Marine Reserve. The remainder of the closed area would be designated as a no-bottom-contact MPA. The objective of these measures would be to provide greater protection to a full range of marine habitats within the 1,000 m bathymetric line (Figure 4.2 5; specific details on the example FMP 3.2 map are provided in Section 4.2.3). The guideline aims to provide greater protection for a wide range of species, from Steller sea lions to slope rockfish to prohibited species, while at the same time respecting traditional fishing grounds and maintaining open area access for coastal communities. Additionally, the bookend would extend the existing bottom-trawl ban on pollock to the GOA.

Additional conservation benefits would be realized in example FMP 3.2 through the comprehensive rationalization of all fisheries (except those already part of a cooperative or IFQ program.) In adopting rationalization programs such as cooperative-style programs with built-in community protections, habitat and bycatch concerns would also be addressed by reducing concentrated effort in the fisheries. To increase precautions regarding bycatch, PSC limits would be significantly reduced (and set for all prohibited species in the GOA), but would not be expected to act as a proportionate restraint on the fisheries due to the incentives for bycatch reduction under cooperatives, or other bycatch incentive programs implemented as necessary under this bookend.

In accordance with ecosystem principles, the NPFMC and NOAA Fisheries would seek to initiate joint consultation and research with USFWS to develop fishing methods that reduce incidental take of all seabird

species. Formal procedures would also be implemented to increase consultation with and representation of Alaska Natives in fishery management.

Effective monitoring and timely reaction to change in the environment and the fisheries would be enhanced through increase of observer coverage and improvements to the observer program, as well as an increase in the use of VMS and the range of economic data collected from industry.

Alternative 4 – Adopt a Highly Precautionary Management Policy

Alternative 4 represents an extremely precautionary approach to managing fisheries under scientific uncertainty. This type of management policy shifts the burden of proof to the users of the resource and the NPFMC/NOAA Fisheries to demonstrate that the intended use would not have a detrimental effect on the environment. It would involve a strict interpretation of the precautionary principle. Management discussions would involve and be responsive to the public, but would decrease emphasis on industry and community concerns in favor of ecosystem processes and principles. This policy assumes that fishing does produce adverse impacts on the environment, but we have little information regarding these impacts. The initial restrictive and precautionary conservation and management measures would be modified or relaxed when additional, reliable scientific information becomes available. For the full text of the alternative, see Section 2.6.5.

Example FMP 4.1

Example FMP 4.1 illustrates an FMP where current levels of fishing are reduced and other precautionary restrictions are implemented until scientific research shows that the fisheries have no adverse effect on the sustainability of the resource and the environment. Example FMP 4.1 is described in full in Table 4.2-1.

Example FMP 4.1 would substantially reduce the potential of the fisheries to have adverse environmental impacts on the environment. A modified TAC-setting process would create a more substantial buffer between ABC and the OFL by setting the fishing mortality rate at $F_{75\%}$ for all Steller sea lion prey species (pollock, Pacific cod, and Atka mackerel) and for rockfish (a long-lived, slow-growing species). Also, the max F_{ABC} for each stock or stock complex in Tiers 1 through 5 would be adjusted downward based on the lower bound of a confidence interval surrounding the survey biomass estimate. OY would be specified separately for each stock or stock complex rather than for the groundfish complex as a whole (i.e., OY would be set as a formula rather than as a range, eliminating the BSAI 2 million mt OY cap), and would be set equal to the respective stock or stock complex TAC. The current precautionary practice of setting TAC less than or equal to ABC would be formalized in the FMP. For species managed as members of a stock complex, rather than setting TAC as the aggregate of the individual members' ABCs, the max_{ABC} value for each stock would be determined and the TAC set equal to the lowest value. Where sufficient biological information is available, such as with EBS pollock, TAC would be distributed on a smaller spatial scale. MSSTs would be determined for all tiers.

To further mitigate the possibility of the fisheries having a detrimental biological and ecosystem impact, 20 to 50 percent of the EEZ would be designated as a No-Take Marine Reserve (i.e., no commercial fishing), covering the full range of marine habitats within the 1,000-m bathymetric line (Figure 4.2-6; specific details on the example FMP 4.1 maps are provided in Section 4.2.3). As part of this area in the Aleutian Islands, a Special Management Area would be established to protect coral and other live bottom habitats. The closed

area would include spawning reserve areas for intensively fished species. Under the FMP 4.1 example, comprehensive trawl exclusion zones would be set to protect all Steller sea lion critical habitat, and trawling would be restricted to only those fisheries that cannot be prosecuted with other gear types (i.e, the flatfish fisheries).

In an effort to reduce waste and the risk of adverse impact to the environment, existing PSC limits would be halved under this bookend, as would bycatch (discard) and incidental catch rates. IR/IU would be extended to all target species. Stringent PSC limits would be set for salmon, crab, and herring in the GOA, and as information becomes available, bycatch limits would be set for non-target species also. Protection measures would be set for all seabird species.

Because this policy alternative necessitates greater research and data-gathering efforts, example FMP 4.1 would expand observer coverage to 100 percent for all vessels over 60 ft in length and require 30 percent observer coverage on vessels presently exempted from observer coverage (i.e., vessels under 60 ft in length). VMS would be made mandatory for all groundfish vessels, as would motion-compensated scales for weighing all catches at sea or at shore-based processors. Cooperative research and data-gathering programs would be initiated as well to expand the use of traditional knowledge in fisheries management.

Example FMP 4.2

Example FMP 4.2 expands the precautionary principles of Alternative 4 by suspending all fishing until the fisheries can be shown to have no adverse effect on the resource and its environment. The TAC for all species would be set at zero. All areas of the EEZ would be closed to all types of fishing (e.g., commercial, recreational, and subsistence) (Figure 4.2-7; specific details on the example FMP 4.2 map are provided in Section 4.2.3); bycatch and incidental catch, as well as the take of seabirds and marine mammals, would then be reduced to zero. Example FMP 4.2 is described in full in Table 4.2-1.

Scientific research and data-gathering efforts would continue. When a fishery can be shown to pose no significant threat of adverse biological and environmental impacts, or if adverse effects can be successfully mitigated through use of fishery-specific regulations, fishing would be allowed to resume.

Under this FMP illustration, it is assumed that each groundfish fishery currently conducted in federal waters in the BSAI and GOA would be individually reviewed by the NPFMC and NOAA Fisheries. Upon completion of this review (which may take up to 2 years), the agency would certify those fisheries that have no significant adverse impacts on the environment and authorize fishing under a specific set of regulations. If a fishery is found by this review to produce significantly adverse environmental effects, and mitigation measures can not be designed to mitigate those effects, that fishery would not be certified and would remain closed until more scientific information is known.

The Preferred Alternative

The preliminary Preferred Alternative represents a management approach that incorporates forward looking conservation measures that address differing levels of uncertainty. This management approach has, in recent years, been labeled the precautionary approach. As part of its policy, appropriate measures would be considered and adopted that accelerate the precautionary, adaptive management approach through community or rights-based management, ecosystem-based management principles that protect managed species from

overfishing, and, where appropriate and practicable, increased habitat protection and bycatch constraints. This management approach recognizes the need to balance many competing uses of marine resources and different social and economic goals for fishery management, and will utilize and improve upon the NPFMC and NOAA Fisheries' existing open process to involve the public in decision-making. For the full text of the alternative, see Section 2.6.9.

Example FMP PA.1

Example FMP PA.1 illustrates a conservative management approach that continues current risk-averse management practices, increases conservation-oriented constraints on the fisheries as appropriate, formalizes precautionary practices in the FMPs, and initiates scientific review of existing practices in order to assess and improve fishery management. Example FMP PA.1 is described in full in Table 4.2-2.

Example FMP PA.1 builds on the existing conservative procedure for determining ABC and annual quotas. The example FMP would implement changes to the TAC-setting process following a comprehensive review. Precautionary practices, such as setting TAC less than or equal to the ABC, and specifying MSSTs for Tiers 1 through 3 in accordance with National Standard Guidelines, would be formalized in the FMP. The NPFMC and NOAA Fisheries would continue to use and improve harvest control rules to maintain a spawning stock biomass with the potential to produce sustained yields on a continuing basis, and to distribute allocations by area, season, and gear as appropriate. Efforts to develop ecosystem indicators to be used in TAC-setting, as per ecosystem management principles, would be continued.

In order to balance the needs of social and economic stability with habitat protection and resource conservation, the NPFMC would develop an MPA efficacy methodology, including the development of definitions, program goals, objectives, and criteria for establishing MPAs. Additionally, existing habitat and bycatch area restrictions would be maintained. Measures to protect ESA-listed species would also be retained. To minimize bycatch, a moderate reduction of PSC limits in the BSAI would be initiated, and PSC limits or other appropriate measures for the protection of crab, herring, and salmon would be authorized in the GOA. Effective monitoring and timely reaction to change in the environment and the fisheries would be enhanced through improvements in the observer program and existing reporting requirements.

Existing programs to address excess capacity and overcapitalization would be maintained under this example FMP, with continued development of rights-based management to be undertaken as needed. In order to mitigate any adverse impacts of fisheries management decisions on fishing communities, and to comply with other national directives, procedures to encourage increased participation of Alaska Natives in fishery management would be pursued.

Example FMP PA.2

Example FMP PA.2 accelerates adaptive, precautionary management by increasing conservation measures that provide a buffer against uncertainty, instituting research and review of existing measures, and expanding data collection and monitoring programs. Example FMP PA.2 is described in full in Table 4.2-2.

Example FMP PA.2 significantly increases precautionary management by incorporating an uncertainty correction into the estimation of ABC for all species. The current precautionary practice of setting TAC less than or equal to ABC would be formalized in the FMP. The calculation of te OY caps would be periodically

reviewed to determine their relevancy to current environmental conditions and stock levels. Example FMP PA.2 would also develop and implement criteria for using key ecosystem indicators in TAC-setting, and other precautionary practices such as developing appropriate harvest strategies for rockfish stocks. In implementing this bookend, analysis and data collection would allow for specification of MSSTs for priority stocks in Tiers 4 and 5. The development of criteria to manage target and non-target species consistently, and for moving stocks from the Other Species and Non-specified Species management categories, would initially consider moving sharks (in the BSAI and GOA) and skates (in the BSAI) out of the Other Species group for setting TAC limits.

Example FMP PA.2 also re-examines area restrictions in the BSAI and the GOA by reviewing existing closure areas (for closure areas under example FMP PA.1, see Figure 4.2-8 and Section 4.2.3), and evaluating them in conjunction with the development of MPAs. The example FMP would adopt MPAs, based on a designation guideline of 0 to 20 percent of the EEZ (3 to 200 nm). The objective of these measures is to provide greater protection to a full range of marine habitats within the 1,000 m bathymetric line (Figure 4.2-9; specific details on the example FMP PA.2 map are provided in Section 4.2.3). This MPA would incorporate an Aleutian Islands management area to protect coral and live bottom habitat, and would also include any modification to the 2002 Steller sea lion closures. The guideline aims to provide greater protection for a wide range of species, from Steller sea lions to slope rockfish to prohibited species, while at the same time respecting traditional fishing grounds and maintaining open area access for coastal communities. Additionally, the bookend would extend the existing BSAI bottom-trawl ban on pollock to the GOA.

To increase precautions regarding bycatch, existing PSC limits would be reduced, and limits would be set for all prohibited species in the GOA with appropriate in-season closure areas. The achievement of these bycatch reductions would be realized through the comprehensive rationalization of all fisheries (except those already part of a cooperative or IFQ program), which reduces concentrated effort in the fisheries, or through bycatch incentive programs implemented in this example FMP.

In accordance with ecosystem principles, the NPFMC and NOAA Fisheries would seek to cooperate with USFWS to develop fishing methods that reduce incidental take of all seabird species in the longline and trawl fleets. Procedures would also be pursued to increase consultation with and representation of Alaska Natives in fishery management.

Increases in observer coverage and improvements to the observer data that are collected would enhance effective monitoring and improve the ability to react to change in the environment and the fisheries. Additionally, the bookend explores programs that would expand mandatory economic data collected from industry.

4.2.3 Description of the Example Fishery Management Plan Maps

FMP 1 Map

FMP 1 (Figure 4.2-1) illustrates different types of spatial management areas across the BSAI and GOA. All of these areas currently comprise the spatial management regime for 2003. These areas are color-coded on the map; bathymetry contours to 1,000 m are also color-coded, ranging from dark green (0 m) to a pale beige (1,000 m). In the legend, titles for measures developed specifically for protection of Steller sea lions are

printed in blue. Bycatch closures that are triggered once a PSC limit is reached are not included on the map or in the spatial analysis, since in recent years some of these limits are no longer reached.

FMP 1 illustrates the current Steller sea lion-related closures west of 144°W longitude necessary for the Alaska groundfish fisheries to avoid a determination of jeopardy and adverse modification for Steller sea lions under the ESA. The Steller sea lion population west of 144°W longitude has been listed as endangered under the ESA since 1990. The portion of the Steller sea lion population found east of 144°W longitude is currently listed as threatened. Closures related to protection of Steller sea lions are color-coded as follows:

Yellow:	3 nm No-Transit Zones (No-Take Reserves)
Blue:	No Hook-and-Line and Pot or Trawl for the Steller Sea Lion Prey Species
Red:	No Trawling for Steller Sea Lion Prey Species
Red Hatching:	Seasonal and Harvest Limit Closures for Atka Mackerel and Pacific Cod
Tan Hatching:	Additional Atka Mackerel Closures
Blue Hatching:	Additional Pollock Closures

The No-Transit Zones shown on the map have been in effect since 1992, and serve to restrict all water-born vessel traffic year-round, unless under a federal scientific permit.

Areas designated as "No Hook-and-Line and Pot or Trawl for Steller Sea Lion Prey Species" are those areas that currently restrict the harvest of Steller Sea lion prey species by hook-and-line and pot and bottom and pelagic trawl gear. These restrictions are in effect year-round.

Areas labeled "No Trawling for Steller Sea Lion Prey Species" restrict both bottom and pelagic trawl fishing for Steller sea lion prey species and are in effect year-round.

In the BSAI, areas designated as "Seasonal and Harvest Limit Closures for Atka Mackerel and Pacific Cod" are those areas where Atka mackerel fishing is closed all year within 20 nm of Steller sea lion rookeries and haulout sites in waters east of 178°W longitude. In waters west of 178°W longitude, constraints on Atka mackerel harvest are triggered once 40 percent of the Aleutian Islands Atka Mackerel TAC is reached. After the 40 percent threshold is reached in the Aleutian Islands, all other Atka mackerel fishing must occur at least 20 nm from Steller sea lion rookeries and haulout sites. To prevent localized depletion of prey species, Pacific cod (which are managed under a single TAC for the BSAI) may not be targeted west of 178°W longitude after 40 percent of that BSAI TAC is reached.

Additional closures include those areas closed to directed fishing of Atka mackerel and pollock, The GOA west of 144°W longitude is closed year-round to directed fishing for Atka mackerel. The entire Aleutian Islands subarea is closed year-round to directed fishing of pollock, and both the GOA and the Bering Sea have additional seasonal pollock restrictions.

Non-Steller sea lion related spatial closures, including areas closed to all trawl, non-pelagic trawl, and all fishing, are presented in the example FMP 1, FMP 2.2, and FMP 3.1 maps (Figures 4.2-1, 4.2-3, and 4.2-4, respectively). These closures include the following areas:

Closed to All Trawl

- Nearshore Bristol Bay Closure Area: Bering Sea area closed year-round since 1996.
- Pribilof Islands Area Habitat Conservation Zone: Bering Sea area closed year-round since 1994.
- Southeast Outside Closed Area: closed year-round since 1997.
- Chiniak Gully Research Area: closed from August 1 through September 20.

Closed to Non-Pelagic Trawl

- Red King Crab Savings Area: Bering Sea area closed year-round since 1996.
- Kodiak Type I Crab Closure Areas: GOA area closed year-round.
- Kodiak Type II Crab Closure Areas: GOA area closed between February 15 to June 15.

Closed to All Fishing

- Cape Edgecumbe (Sitka) Pinnacles: closed to groundfish fishing year-round since 1997.

All of these spatial measures (closures) combined protect 10.7 percent of the EEZ (Table 4.2-3). Because groundfish resources and EFH are usually found to be associated with the continental shelf and continental slope, for purposes of this analysis we have defined "fishable area" as those waters over the continental shelf and continental slope, or all waters to a depth of 1,000 m. When examined in this way, the spatial measures described for example FMP 1 protect 28.8 percent of the fishable area of the BSAI and GOA. (Table 4.2-3).

Example FMP 2.1 Map

The map for example FMP 2.1 (Figure 4.2-2) illustrates six different types of spatial management areas across the BSAI and GOA. Example FMP 2.1 includes only the current Steller sea lion-related closures west of 144°W longitude, necessary for the Alaska groundfish fisheries to avoid a jeopardy determination for Steller sea lions under the ESA. These closure areas are color-coded on the map; bathymetry contours to 1,000 m are also color-coded, ranging from dark green (0 m) to a pale beige (1,000 m). Closures related to protection of Steller sea lions are color-coded as follows:

Yellow:	3 nm No-Transit Zones (No-Take Reserves)
Blue:	No Hook-and-Line and Pot or Trawl for the Steller Sea Lion Prey Species
Red:	No Trawling for Steller Sea Lion Prey Species
Red Hatching:	Seasonal and Harvest Limit Closures for Atka Mackerel and Pacific Cod
Tan Hatching:	Additional Atka Mackerel Closures
Blue Hatching:	Additional Pollock Closures

Descriptions of these six spatial management areas do not deviate from those presented under the FMP 1 map at the beginning of this section. All of these spatial measures (closures) combined protect 4.2 percent of the EEZ, and 14.6 percent of the fishable area of the BSAI and GOA (Table 4.2-4).

Example FMP 2.2 and Example 3.1 Maps

The maps for examples FMP 2.2 and FMP 3.1 are identical to the map for example FMP 1 (Figures 4.2-3 and 4.2-4). See Tables 4.2-5 and 4.2-6 for descriptive statistics on FMPs 2.2 and 3.1, respectively.

Example FMP 3.2 Map

The map for example FMP 3.2 (Figure 4.2-5) illustrates six color-coded spatial management areas. Bathymetry contours to 1,000 m are also color-coded, running from dark green (0 m) to pale beige (1,000 m). In the legend, titles for measures developed specifically for protection of Steller sea lions are printed in blue. Closures are color-coded as follows:

Yellow:	3 nm No-Transit Zones (No-Take Reserves)
Blue:	No-Take Marine Reserves
Dark Green:	No Steller Sea Lion Prey Species Hook-and-Line, Pot, or Trawl Fishing MPA
Purple:	No Steller Sea Lion Prey Species Trawling MPA
Light Green:	Eastern GOA No Steller Sea Lion Prey Species Hook-and-Line, Pot, or Trawl MPA
Pink:	No-Bottom-Contact Trawling MPA

The map has been developed from the following information and data sources: bathymetry; EFH from the 1997 EFH EA (NMFS 1997); Steller sea lion critical habitat; 2002 Steller sea lion closures; survey and bycatch data for coral and sponge distribution; historical commercial fisheries catch data; location of ports; locations of test and study areas; and review of various alternatives and potential mitigation measures being developed by the NPFMC EFH Committee. Using the latest data to determine Steller sea lion foraging behavior, a 15 nm buffer from the coastline in the GOA and Bering Sea was applied, as were 15 nm buffers from Steller sea lion rookeries and haulouts in the Aleutian Islands.

The ADF&G groundfish statistical areas were applied as management units to designate five different types of management areas including No-Take Marine Reserves; No Steller Sea Lion Trawling MPA; No Bottom Trawling MPA; No Steller Sea Lion Hook-and-Line, Pot or Trawl MPA; and, in the eastern GOA, No Steller Sea Lion Hook-and-Line, Pot or Trawl and No-Trawl MPA.

The ADF&G statistical areas are approximately 35 nm wide and 30 nm tall. ADF&G subdivides their statistical areas at 3 nm from the shoreline. These management units, when grouped into larger spatial regions, are presumably large enough to 1) prevent habitat fragmentation; 2) protect large portions of HAPC; 3) form clearly defined, manageable, navigable, and enforceable alternatives; 4) provide contiguous fishing restrictions for protecting spawning populations, key critical habitat, demersal and pelagic fish species, and marine mammals; and 5) where possible, provide open areas near fishing ports.

From a biological and fishery point of view, the ADF&G groundfish statistical area boundaries are arbitrary and do not always line up with the spatial distribution of significant biological and habitat resources. Therefore, a 40 percent rule was applied: when 40 percent of a statistical area had a significant concern as

determined by a weighted qualitative factor, the area was tagged as a "No-Take Marine Reserve", or one of the other MPAs. This effect was normalized to a certain extent during the analysis because a statistical area that did not quite meet the benchmark would not be designated as an MPA (e.g., an area where less than 40 percent was of concern would be left entirely open). In some cases, areas would be totally closed to create a contiguous closure necessary to capture a broad range of inshore to offshore habitats.

The benthic fishing habitat used in this analysis generally follows the continental shelf and goes out to a depth of 1,000 m (500 fathoms), which we consider here to constitute the fishable bottom habitat. Blocks of closures extend from the shore to a 1,000-m depth, protecting a full range of habitat types. Area protected by FMP 3.2 spatial measures, when combined, constitutes 17.8 percent of the EEZ, and 47.8 percent of the fishable area of the BSAI and GOA (Table 4.2-7).

Aleutian Islands

The Aleutian Islands subarea merits special attention since the fishing grounds are all relatively nearshore. Example FMP 3.2 defines a 5 percent No-Take Reserve and 15 percent MPA rule across a full range of habitat types. Where in the Bering Sea and GOA, 15 nm buffers from shore were described in the frameworks, in the Aleutian Islands, a 15 nm buffer was applied to each of the Steller sea lion rookeries and haulouts. This buffer does not specifically implement a No-Take Reserve or other MPA, but is likely to be a weighting factor in any future development of restrictions.

Due to the narrow continental shelf along the Aleutian Island chain, and the fact that state statistical areas are utilized in this Programmatic SEIS, a much higher percentage of fishable area (79.9 percent) is afforded protection in the example FMP 3.2 in the Aleutian Islands area compared to the Bering Sea (32.6 percent) and western/central GOA (65.6 percent).

Thirty-nine Steller sea lion rookeries fall within Steller sea lion critical habitat, 19 of which are located in the Aleutian Islands. All rookeries carry a 3 nm No Transit area with an additional 10 nm (or more) designated as a No Trawling for Steller Sea Lion Prey Species area. The No Transit areas are the only No-Take reserves in the Aleutian Islands. These closures have been in effect since 1992, all of which are logical candidates for no-take marine reserves or MPAs. Many of these Steller sea lion No Transit/No-Trawl areas are clustered and transfer easily to corresponding ADF&G statistical areas. Although other non-Steller sea lion prey species fisheries such as rockfish fisheries, occur inside No Steller Sea Lion Prey Species Trawl areas, these no-trawl areas were weighted heavily in the analysis as representing conceptual No-Take reserves and less so for gear-specific MPAs. Coral data from bycatch and trawl survey data, as well as from NOAA dive test areas, were used in the development of the No-Take marine reserve examples.

The MPAs considered for analysis of example FMP 3.2 include No Steller Sea Lion Prey Species Hook-and-Line, Pot, and Trawling MPAs; No Steller Sea Lion Prey Species Trawling MPAs; and No Bottom Contact Trawling MPAs. To encompass existing closures areas, the Pacific cod Hook-and-Line and Pot and Trawling restrictions were extended to constitute No Steller Sea Lion Prey Species Hook-and-Line and Pot MPAs, if not already closed as No-Take Reserves. Other current Steller sea lion prey species restrictions include closing trawl fisheries for Atka mackerel, pollock (the entire Aleutian Islands subarea), and Pacific cod. To better protect habitat, a suite of MPAs for No Bottom Contact Trawling (currently defined simply as non-pelagic trawling) were created around areas of low and medium fishing intensity areas where bycatch

or trawl survey data contained coral and sponge. Some of these low intensity areas can be seen on Bowers Ridge, west of Attu Island, and west of the Bogoslof District.

Through the development of these no-take reserves and MPAs, the 40 percent rule was applied to ADF&G statistical areas in order to illustrate a contiguous and fairly non-fragmented environment available for marine mammals, benthic habitats, seabird avoidance, and spawning fish populations without jeopardizing commercial fisheries.

Bering Sea

Guidelines in the example FMP 3.2 MPAs and EFH component define a 5 percent No-Take Reserve and a 15 percent MPA rule across a full range of habitat types. Bering Sea benthic habitat is much different than the habitat Aleutian Islands, due to its broad, muddy, and sandy shelf. The Bering Sea also contains many legacy areas established for habitat protection, such as the Near Shore Bristol Bay No-Trawl area, the Red King Crab No Non-Pelagic Trawl area, the Pribilof Habitat No-Trawl area, and a full suite of No Steller Sea Lion Prey Species Hook-and-Line and Pot and Trawl Areas. Other existing closures in the Bering Sea have been used for the creation of No-Take Reserves and MPAs (i.e., five No Transit zones and their associated 10 nm No Steller Sea Lion Prey Species Trawling areas with various sized hook-and-line and pot closures). A large section of the Steller sea lion conservation area (the Bogoslof District) is closed to all Steller sea lion prey species fishing (with a small exemption area near Dutch Harbor for catcher vessels less than 60 ft in length.

A buffer from the shore of 15 nm was used to help determine designation of the No-Take Reserves and the MPAs. As in the Aleutian Islands, we have applied a 40 percent rule to ADF&G statistical areas to illustrate contiguous and fairly non-fragmented environments.

The Bogoslof District currently contains significant amount of No-Take Reserves, along with many No Steller Sea Lion Prey Species Hook-and-Line and Pot and Trawling areas. More No Steller Sea Lion Hook-and-Line and Pot Trawling areas develop to the east along the lower Bering Sea shelf. The 3 nm statistical areas around the land bordering the rookeries are listed as No-Take Marine reserves. Other No-Take Reserves include a large area around the Cape Pierce Walrus Protection area and the Walrus Island Steller sea lion rookery in the Pribilof Islands.

The Pribilof Habitat Conservation and Nearshore Bristol Bay areas remain closed to trawling, and the Red King Crab Savings Area remains closed to non-pelagic trawling. The two northernmost haulouts and the haulouts in the Pribilofs are closed to Steller Sea Lion Prey Species Hook-and-Line and Pot and Trawling.

Along the northwestern shelf of the Bering Sea, three large No-Bottom-Contact Trawling MPAs were developed to coincide with the no-bottom-trawling areas the EFH Committee is considering to protect benthic habitat. These general areas are being considered as potential sites for a rotational MPA, where areas are periodically opened and closed to particular types of fishing.

GOA – West of 144°W

Similar to the BSAI area, example FMP 3.2 sets a 5 percent No-Take Reserve and a 15 percent MPA rule across a full range of habitat types in the GOA (west of 144°W) . Unlike the Bering Sea, however, the GOA

is somewhat more restrictive as to where effective closures can be designated and leaves areas open near fishing ports.

Fifteen Steller sea lion rookeries are listed in the GOA, 13 of which include 3 nm No Transit areas and 10 nm No Steller Sea Lion Prey Species Trawling areas. These areas, along with other existing Steller sea lion restrictions (such as the 15 nm buffers from the shore, the Type I & II No-Trawl areas (areas that are closed year round to all trawling but pelagic gear, and areas that are closed to pelagic gear from Feb 15-June 15, respectively), and the Chiniak Gully Research Area); known locations of Steller sea lions and other marine mammals (such as harbor seals); pollock spawning areas; bycatch and survey data of coral and sponges; the shelf's gullies, canyons, and breaks; and EFH, were used as weighted measures for the illustration of the No-Take Reserves and MPAs in FMP 3.2.

The 40 percent rule was again applied to the ADF&G statistical areas to illustrate large, non-fragmented environments.

In order to protect a full range of habitat, perpendicular tracks of No-Take Marine Reserves were created from the shoreline to a depth of 1,000 m. Where possible, the No-Take Reserves were created at Steller sea lion rookeries and where existing No Hook-and-Line and Pot and Trawl for Steller Sea Lion Prey Species closures coexist, such as at Marmot Island, south Chignik in RPA District 4, selected Steller sea lion rookeries and haulouts, and RPA Districts 10 and 11 (below the Bogoslof District). Other areas that were designated No-Take Reserves for purposes of our analysis included a section of the shelf and slope below the Shumagin islands and Portlock Banks, and smaller sections of the shelf below Prince William Sound (PWS).

When Steller sea lion restrictions were dominant but did not reach the benchmark for creating No-Take Reserves, there were no Steller Sea Lion Prey Species Hook-and-Line and Pot and Trawl closure areas created using the weighted measure. Instead, No-Trawl for Steller Sea Lion Prey Species and No-Bottom-Contact Trawling closures were created using these same sets of weighted criteria.

<u>GOA – East of 144°W</u>

As in the BSAI, example FMP 3.2 for the GOA (east of 144°W longitude) defined a 5 percent No-Take Reserve and a 15 percent MPA rule across a full range of habitat types.

Currently there are no Steller sea lion closures east of 144°W. The Steller sea lion population east of 144°W is listed as threatened; therefore, we included an example measure to provide some protection to this part of the population. The No-Trawl closure east of 140°W was strengthened in this illustration to include an MPA for No Hook-and-Line and Pot or Trawl for Steller Sea Lion Prey Species. The MPA also includes a smaller area near Icy Bay and Cape Yakataga.

The example No-Take Reserves were developed to protect habitat in areas with low to medium fishing intensity and within 3 nm of three Steller sea lion rookeries. The Sitka Pinnacles are located within one of the example No-Take Reserves.

Example FMP 4.1 Map

There are two versions of the example FMP 4.1 map, both of which illustrate the same suite of spatial closures. Figure 4.2-6 provides a map illustration using the same color scheme used in maps for example FMPs 1 through 3.2, so that the maps may be easily compared. Figure 4.2-11 uses the same color scheme (magenta) as the map for example FMP 4.2 map (Figure 4.2-7). Both example FMPs 4.1 and 4.2 illustrate a major shift in management policy from current policy. Unlike current management practice, where any type of fishing is generally permitted unless specifically prohibited (e.g., the maps are blank unless closures/restrictions are shown), the maps for example FMP 4.1 illustrates a management policy where all areas and types of fishing are closed unless shown otherwise. Bathymetry contours to 1,000 m are also color-coded, ranging from dark green (0 m) to pale beige (1,000 m). In the legend, titles for measures developed specifically for protection of Steller sea lions are printed in blue. Figure 4.2-11 illustrates four types of spatial management areas that are color-coded as follows:

Yellow:	3 nm No Transit Zones (No-Take Reserve)
White:	Open to Fishing
Magenta Hatching:	Open to Commercial Fishing Except Trawling
Magenta (solid):	No-Take Marine Reserves

The map has been developed from the following information and data sources: bathymetry; EFH from the 1997 EFH EA (NMFS 1997); Steller sea lion critical habitat; 2002 Steller sea lion closures; survey and bycatch data for coral and sponge distribution; historical commercial fisheries catch data; location of ports; locations of test and study areas; the Aleutian Islands special management area; public comments; and the legacy closures and restricted areas identified in Table 4.2-1.

ADF&G statistical areas were applied as management units to designate open fishing areas, No-Trawling areas (all species, all types of trawls), and No-Take Marine Reserves (where commercial fishing is prohibited). The ADF&G groundfish statistical areas are approximately 35 nm wide and 30 nm tall. ADF&G subdivides their statistical areas at 3 nm from the shoreline. These management units, when grouped into larger spatial regions, are presumably large enough to 1) prevent habitat fragmentation; 2) protect large portions of HAPC; 3) form clearly defined, manageable, navigable, and enforceable alternatives; 4) provide contiguous fishing restrictions for protecting spawning populations, critical habitat, demersal, and pelagic fish species, and marine mammals; and 5) where possible, provide open areas near fishing ports.

From a biological and fishery point-of-view, the ADF&G statistical areas are arbitrary and do not always represent the spatial distribution of significant biological and habitat resources. Therefore, a 25 percent rule was applied in the following manner: when 25 percent of a state statistical area had a significant concern, the area was designated as either a No-Take Marine Reserve or a No-Trawl MPA. This effect was normalized to a certain extent during the analysis because a statistical area that did not quite meet the benchmark would not be designated as an MPA (e.g., an area where less than 25 percent was of concern would be left entirely open, as was the case when attempting to close Steller sea lion critical habitat). In some cases, areas were totally closed, even if the 25 percent benchmark was not reached, to create a contiguous closure that captured a broad range of inshore to offshore habitats.

Area protected by example FMP 4.1 spatial measures, when combined, is 19.0 percent of the EEZ, and 51.1 percent of the fishable area of the BSAI and GOA (Table 4.2-8). The primary difference between this map

and the FMP 3.2 map is that most of the spatial closures used in this illustration are No-Take Marine Reserves where all commercial fishing is prohibited. This form of closure is intended as an extremely precautionary policy that places emphasis on protecting marine mammals, target groundfish stocks, and EFH.

Aleutian Islands

The Aleutian Islands subarea merits special attention since the fishing grounds are near the shore. Example FMP guidelines specify that 20 to 50 percent of each management area, including all representative habitats contained therein, should be managed as a No-Take Marine Reserve. The Aleutian Islands Special Management Area illustrated in example FMP 4.1 covers a contiguous area specifically to protect coral and other living substrates; and Steller sea lion critical habitat. Although the Aleutian Islands Special Management Area was originally intended to encapsulate the entire Aleutian Islands subarea, excluding a swath of fishable area at Unimak Pass, this is not shown on the map since the Bogoslof District and RPA Districts 10 and 11 are already analyzed as No-Take Marine Reserves in their own regions.

Benthic fishing habitat to a depth of 1,000 m (500 fathoms) was used in this analysis, which we considered fishable bottom habitat. In most cases, perpendicular blocks of closures extend from one side of the 1,000 ms contour to the other, protecting a full and broad range of habitat.

Thirty-nine Steller sea lion rookeries are located within designated Steller sea lion critical habitat; 19 of which are contained in the Aleutian Islands. All rookeries have a 3 nm No-Transit Zone and an additional 10 nm No Steller Sea Lion Prey Species Trawling area. These closures have been in effect since 1992, all of them making excellent candidates for No-Take Marine Reserves under Alternative 4 policy. Many of these areas are clustered and would transfer easily to the corresponding ADF&G statistical areas. Areas that currently have high densities of no-trawl, hook-and-line, and pot fishing were designated No-Take Marine Reserves in the example FMP 4.1 illustration. A good example of this can be seen in the area from 170°W to Seguam Pass. Blocks on the Petrel Banks were closed due to high coral bycatch. A string of closed statistical areas are located along the Petrel Banks because these areas have had at least some coral bycatch and are relatively unstudied. One block on the southeastern side of Petrel Banks (north slope) was left open. Historically high catch rates in this area and a need to create at least some open areas for fishing prompted this action. No-take reserves along Steller sea lion critical habitat and the 1,000 ms contour created significant contiguous benthic and biologic protection in the Aleutian Islands.

Bering Sea

Example FMP 4.1 guidelines specify that 20 to 50 percent of each management area, including all representative habitats contained therein, should be managed as No-Take Reserves. Specifically mentioned in example FMP 4.1 are submarine canyons, Unimak Pass, old Crab Pot Sanctuary, areas near the Pribilof Islands, area southwest of St. George, Misty Moons, and the Red King Crab Savings Area. These examples were recommended by public stakeholders as candidate areas for analysis in this Programmatic SEIS.

Steller sea lion critical habitat (including the entire Steller Sea Lion Conservation Area) was closed to trawling as an illustration of a No-Trawl MPA, or designated as No-Take Marine Reserves, as were other legacy closures such as the Nearshore Bristol Bay No-Trawl area. And since the Bering Sea has a much broader benthic plane, more options were available to analysts for illustrating a management scenario

meeting the criteria of example FMP 4.1 by protecting a full range of habitat types using a combination of both No-Trawl MPAs and No-Take Marine Reserves.

For purposes of this analysis, we designated the Bogoslof District (RPA District 9) as a No-Take Marine Reserve, with blocks of reserve leading east to include large portions of old Crab Pot Sanctuary Area, thereby illustrating continued protection of this important crab spawning area. A tract of No-take Marine Reserve leaves the old Crab Pot Sanctuary area running north to intercept the coast near Cape Pierce and the Walrus Islands closures. A track of No-Trawl MPA extends from Cape Pierce to the west, intercepting the No-Trawl Marine Reserve formed by the Pribilof Conservation Area. Below the Pribilof Conservation Area is Misty Moon canyon; a No-Take Marine Reserve was designated here because of historically high bycatch of corals and sponges. An open fishing area was created both to the north and south of the Misty Moon area to permit groundfish fishing where catches have been historically good, but with lower bycatch. For purposes of illustrating this policy, other large No-Take Marine Reserves were designated along the inner, middle, and outer Bering Sea shelf breaks. The five northern Steller sea lion haulouts became No-Take Marine Reserves using coincident ADF&G statistical areas. Unlike the Aleutian Islands, the area analysis includes only that part of the ADF&G statistical area that coincides with 1,000 m bathymetry. The exception is that the Bogoslof foraging area is included in the percentage of Bering Sea EEZ calculation.

GOA – West of 144°W

As with the BSAI, GOA (west of 144°W) guidelines suggest that 20 to 50 percent of each management area, including all representative habitats contained therein, should be managed as No-Take Marine Reserves. Specific areas mentioned for analysis are the Davidson Banks, Shumagin Islands, the Type I & II area to the southeast of Kodiak Island, and the Gulf shelf breaks. Unlike the Bering Sea , the GOA is somewhat more restrictive as to where effective closures can be created, while leaving some areas open.

Steller sea lion critical habitat, current Steller sea lion-related closures (trawl, hook-and-line, and pot), pollock spawning areas, fishing ports, and the shelf's gullies, canyons and breaks, were taken into account in the creation of No-Take Marine Reserves and No-Trawl MPAs. In order to protect a full range of habitat, perpendicular tracks of No-Take Marine Reserves were created using ADF&G statistical areas from the shoreline to the 1,000-m break. Where possible, these No-Take Marine Reserves were created at Steller sea lion rookeries and where current Steller sea lion no-trawl and no hook-and-line and pot closures coexist, such as Marmot Island and RPA Districts 4, 10, and 11. Other areas that were designated as No-Take Marine Reserve in this example FMP included the Shumagin Islands (an important pollock spawning area and high catch area), a portion of Davidson Bank, Portlock Banks shelf break, and blocks of areas in and around PWS. Unlike the Aleutian Islands, the area analysis in the GOA (west of 144°W) includes only that part of the ADF&G statistical area that coincides with 1,000 m bathymetry.

GOA – East of 144°W

Because the Southeast Outside District does not include Steller sea lion critical habitat but currently has a trawl ban east of 140°W, this area was analyzed separately from the western and central GOA. Again, a suggested 20 to 50 percent of each management area, including all representative habitats contained therein, should be managed as No-Take Marine Reserves. The Sitka Pinnacles are is the only area currently designated as No-Take among the example FMPs. Coral and sponge bycatch, shelf breaks, and proximity to ports were used in the illustration of No-Take Marine Reserves. The No-Take Marine Reserves protect

a full range of habitat from the coast to the 1,000 m (fishable area) shelf break. Unlike the Aleutian Islands, the area analysis for the GOA (east of 144°W) includes only that part of the ADF&G statistical area that coincides with 1,000 m bathymetry.

Example FMP 4.2 Map

The map for example FMP 4.2 (Figure 4.2-7) illustrates a management plan that completely closes the EEZ to groundfish fishing until such time that NPFMC and NOAA Fisheries have reviewed each fishery and determined whether the fishery will result in any significant adverse impacts on the physical or biological environment. The process of review, certification, and development of fishery-specific regulations could take up to two years, at which time those fisheries authorized to harvest groundfish would be permitted. This map would then change for those fisheries, with certain areas opening to them. Some fisheries may never receive authorization. As fisheries are authorized, their fishery-specific maps would begin to look similar to the example FMP 4.1 map illustrations, depending on the fishery (Table 4.2-9).

For purposes of this programmatic analysis, the map for example FMP 4.2 provides an opportunity to estimate the economic and social value of the commercial groundfish fisheries and realize the impact of a temporary suspension of groundfish fishing. Such a management plan serves as a useful bookend for comparing this example FMP scenario with example FMP 4.1, which illustrates a significantly reduced fishery in lieu of total suspension.

Example FMP PA.1

The map for example FMP PA.1 (Figure 4.2-8) is identical to the map for example FMP 3.1.

Example FMP PA.2

The map for example FMP PA.2 (Figure 4.2-9) is identical to the map for example FMP 3.2.

4.3 Overview of Fishery Management Plan Components and Qualitative Analysis Papers

As introduced in Section 4.1, each of the 11 FMP components in the analytical framework is analyzed in relative isolation of other components. The analysis is intended to provide insight into the range of management tools and measures that can be used to address individual or multiple policy objectives, as well as to address the specific management measures that are included in the example FMPs. Each FMP component paper presents an illustration of how the measures could work and what the environmental consequences would be, based on a review of the scientific literature and past management experience in Alaska and elsewhere. These qualitative analysis papers serve to describe the historical use of the component and provide details on the impacts of the measures themselves. Because each FMP component is analyzed in isolation of the others, however, the papers by themselves do not predict impacts at the alternative level, as they do not take into account the accumulated changes (for example, Steller sea lion protection measures are applied in combination with the creation of MPAs or the reduction in catch limits). The alternatives as a whole are analyzed later in this chapter.

This section contains the abstracts of the 11 qualitative analysis papers prepared for each of the FMP components in the analytical framework. The full text of the papers can be found in Appendix F.

4.3.1 The Total Allowable Catch-Setting Process

The different policy alternatives bear numerous implications for the annual process of setting TAC for the groundfish fisheries. The qualitative analysis paper examines how various constraints on harvest compare between the alternatives. Five aspects of the TAC-setting process are reviewed: 1) the structure and composition of groundfish management categories such as target fish; 2) the setting of OFLs and ABC; 3) the setting of OY and TAC; 4) the MSST required by the National Standards Guidelines for implementing National Standard 1 of the MSA, but which is not currently operative for certain groundfish fisheries in the BSAI and GOA; and 5) the ecosystem implications of the TAC-setting process. Under Alternative 1, existing constraints would be retained in their present configuration. The more aggressive harvest strategies proposed under Alternative 2 could lead to the relaxing of certain constraints. Conversely, the increasingly precautionary and risk-averse policies of Alternatives 3 and 4 would lead to a tightening of those constraints. For further detail on this FMP component and its likely environmental consequences, see Appendix F-1.

4.3.2 Spatial/Temporal Management of Total Allowable Catch

The times at which the groundfish fisheries may be open to allow fishing, and the areas that may be fished provide crucial variables for fisheries managers, who allocate the TACs by spatial/temporal determinations appropriate to various biological, environmental, and economic concerns. This qualitative analysis paper provides a broad overview of the current rationale for spatial/temporal management of the target fish TACs and examines how the measures identified in the alternatives and their FMP bookends would impact the spatial/temporal management of the target groundfish TACs. Potential changes would occur under Alternatives 3 and 4, where measures would be taken to manage all species on smaller spatial/temporal scales. For further detail on this FMP component and its likely environmental consequences, see Appendix F-2.

4.3.3 Marine Protected Areas and Essential Fish Habitat

Protection of marine habitats is an integral component of the groundfish FMPs for the BSAI and GOA. This qualitative analysis paper provides a review of proposed closure areas under the four policy alternatives and their direct/indirect effects on EFH and other aspects of the biological, physical, social, and economic environments. Beyond the continuation of the present risk-averse policy under Alternative 1, the more aggressive harvest policy of Alternative 2 assumes that present policy is overly conservative and may allow the opening of certain areas presently closed with the exception of Steller Sea Lion Protection Measures. Alternatives 3 and 4 represent increasingly risk-averse policies that would increase habitat protections and reduce fisheries impacts on habitat. For further detail on this FMP component and its likely environmental consequences, see Appendix F-3.

4.3.4 Steller Sea Lion Measures

Protection of Steller sea lions from potentially adverse impacts by the BSAI and GOA groundfish fisheries has been a component of the FMPs since 1990, when Steller sea lions were listed under the ESA. After a review of background information available on the decline of Steller sea lions and hypotheses for the decline, this qualitative analysis paper describes the current protection measures in place and evaluates the qualitative impacts of the four alternatives, as represented by their respective FMP bookends, on Steller sea lions. The present Steller sea lion protection measures, described in Alternative 1, are also included in the policies of Alternatives 2 and 3. Alternative 2, however, proposes a less precautionary approach that views additional regulatory safeguards as unwarranted. Alternative 3 assumes a greater impact on a number of environmental factors and consequently places more emphasis on research and on improving monitoring and enforcement of fishing restrictions within Steller sea lion critical habitat. Alternative 4 substantially increases protections for Steller sea lions by providing for a more conservative, risk-averse approach than the first three alternatives. Under Alternative 4, uncertainty about impacts and the shifting of the burden of proof would lead to significant reductions in current TACs and the establishment of larger buffer zones to further separate the groundfish fisheries from Steller sea lion critical habitat. The NPFMC could choose to suspend all fishing entirely until each fishery could be reviewed and certified as resulting in no significant adverse impacts. Certified fisheries would be subjected to more scrupulous monitoring and enforcement to ensure compliance with restrictions. A key component of all four alternatives is the requirement to remain in compliance with the ESA, and any changes that substantially alter the underlying requirements would require further Section 7 consultations under ESA. For further detail on this FMP component or its likely environmental consequences, see Appendix F-4.

4.3.5 Bycatch and Incidental Catch Restrictions

Bycatch is defined in the MSA as fish that are harvested in a fishery, but which are not sold or kept for personal use. This includes the portion of catch that is discarded back into the sea, and unobserved mortality due to a direct encounter with fishing gear that does not result in the capture of that species by a fisherman. The latter includes mortality due to lost or discarded fishing gear, as well as dropoff and escapement mortality. Discards include species that must be returned to the sea by law (known as regulatory discards), and fish that are discarded at the discretion of the fisherman because they are not worth keeping (know as economic discards). This qualitative analysis paper provides a broad overview of the different bycatch species and the four proposed policy alternatives as they pertain to the regulation of bycatch in the groundfish fisheries of the BSAI and GOA. Beyond the status quo policy of Alternative 1, the more aggressive harvest

strategies of Alternative 2 could remove some of the current protections for some bycatch species. Conversely, added protections under Alternatives 3 and 4 would increase protection for at-risk bycatch species. The more restrictive bycatch limitations proposed under Alternatives 3 and 4 could place greater economic burdens on the groundfish industry. The rationalization and bycatch reduction incentive programs included in FMP 3.2 would tend to decrease the cost and increase the benefit of reducing bycatch for individual fishing operations. This would make further reductions in bycatch practicable, address the source of the problem of excess bycatch, and decrease the need for less efficient command and control solutions to the bycatch problems. For further detail on this FMP component and its likely environmental consequences, see Appendix F-5.

4.3.6 Seabird Measures

More than 70 species of seabirds occur over waters off Alaska and could potentially be affected by direct and indirect interactions with the federal groundfish fisheries off Alaska. This qualitative analysis paper compares the four policy alternatives and their respective FMP bookends specifically in regard to those management measures designed to protect seabirds. The four alternatives cover a wide range of possibilities for the evolution of seabird protection measures. Alternative 2 would require the minimum protection necessary to comply with the ESA concerning listed seabird species. Alternative 3 would place more emphasis on reducing incidental takes of all species of seabirds by improving seabird deterrent devices and avoidance techniques. Alternative 3 would also expand the Observer Program to improve the quality and amount of data collected on seabirds. Alternative 4 would seek to reduce incidental seabird take to levels approaching zero, in large part through the reduction in fishing effort until respective fisheries can be certified as having no adverse environmental impact. For further detail on this FMP component and its likely environmental consequences, see Appendix F-6.

4.3.7 Gear Restrictions and Allocations

Allocation of fishing privileges among users of different gear types is an important tool for managing the groundfish fisheries to achieve a number of biological and socioeconomic objectives. This qualitative analysis paper discusses current and proposed gear restrictions and allocations in the BSAI and GOA groundfish fisheries. The paper begins by identifying various types of management tools used to address allocation issues or implement allocation decisions, focusing particularly on gear restrictions. The paper then describes recent trends in the application of such allocation measures in the Alaska groundfish fisheries and concludes with a qualitative comparison of the impacts of the alternatives on gear restrictions. Alternative 1 would maintain current gear restrictions and allocations in the Alaska groundfish fisheries, as would FMP bookends 2.2 under Alternative 2 and 3.1 under Alternative 3. Example FMP 2.1, however, would eliminate all trawl and fixed gear restrictions, as well as trawl closure areas, with the exception of those closures implemented to protect Steller sea lions. The remaining, increasingly restrictive FMP bookends (example FMPs 3.2, 4.1, and 4.2) place greater prohibitions on the use of non-pelagic bottom trawl gear to harvest pollock in the GOA (example FMP 3.2); prohibit trawling in all fisheries that can be prosecuted with other gear types (example FMP 4.1); and prohibit all fishing for groundfish in the EEZ off Alaska (example FMP 4.2). For further detail on this FMP component and its likely environmental consequences, see Appendix F-7.

4.3.8 Overcapacity

Fishing capacity is the ability of a vessel or fleet of vessels to catch fish. Overcapacity occurs in an open access or regulated open access fishery where the race for fish induces fishermen to put increasingly more time, money, and effort into competing with other fishermen to maintain their share of the TAC. This qualitative analysis paper provides a discussion of various management systems for limiting effort and reducing excess capacity under the four policy alternatives. Alternative 1 would retain present effort limitation programs, such as the sablefish IFQ Program. Under the more aggressive harvest strategies of Alternative 2, such programs would be repealed with the exception of effort limitation measures under the AFA. The increasingly risk-averse policies represented by Alternatives 3 and 4 would either maintain or augment existing effort limitations programs. The paper speculates, however, that the extremely risk-averse policy of example FMP 4.2 would lead to extreme conditions of overcapacity. For further detail on this FMP component and its likely environmental consequences, see Appendix F-8.

4.3.9 Alaska Native Issues

Marine resources have always been an important part of the lives of Alaska Natives, both as subsistence resources and as integral parts of their different cultures. Consequently, changes in fisheries management policy proposed under the alternatives would have socioeconomic impacts on Alaska Natives. This qualitative analysis paper offers an analysis of those potential impacts, as well as the impacts that Alaska Natives themselves may have on management of the fisheries. Alaska Natives contribute to management through representation on the NPFMC and its Advisory Panel, through input into the decision-making process, and through the integration of local and Traditional Knowledge into scientific understanding of the resources and their environment. After reviewing issues of representation and input implicated by the alternatives, this paper proceeds to review impacts the alternatives may have on subsistence issues and concomitant concerns in regard to Environmental Justice for Alaska Natives. Measures contained in the FMP bookends for Alternatives 2 and 4 that would restrict or repeal the CDQ program or proscribe subsistence fishing would result in significant adverse impacts on the Native communities that rely on such fisheries. For further detail on this FMP component and its likely environmental consequences, see Appendix F-9.

4.3.10 The Observer Program

The North Pacific Groundfish Observer Program collects, maintains, and distributes data for the fisheries scientists and managers who must rely on such data to fulfill their responsibilities under the MSA. This qualitative analysis paper provides a description of the administration and operations of the Observer Program in detail and a qualitative discussion of the need for and impact on observer coverage under each of the four policy alternatives. The most drastic impacts would occur under Alternative 2. Example FMP 2.2 would leave the Observer Program essentially the same as at present, and example FMP 2.1 would virtually eliminate the Observer Program and its data collection activities. With the exception of AFA and CDQ pollock and crab fisheries, all other fisheries would cease to be monitored by observers, and the amount of data available for inseason management, as well as for scientific investigation, would be drastically reduced. Under the increasingly risk-averse policies of Alternatives 3 and 4, the Observer Program would either remain basically the same as at present (example FMP 3.1) or be modified to allow for increased observer coverage and data-collection (example FMPs 3.2, 4.1, and 4.2). For further detail on this FMP component and its likely environmental consequences, see Appendix F-10.

4.3.11 Data and Reporting Requirements

The MSA states that the collection of reliable data is essential to the effective conservation, management, and scientific understanding of the fishery resources of the United States. This qualitative analysis paper examines the effects of alternative approaches to data collection in the Alaska groundfish fisheries, focusing on the information collected from industry reporting requirements and VMS requirements for the groundfish fisheries. Alternative 1 and example FMP 2.2 would retain current reporting requirements. Example FMP 2.1 would eliminate measures requiring use of VMS and at-sea weighing of catch, except by catcher processors operating under the AFA. At present, the economic data collected on a routine basis are insufficient for a comprehensive regulatory analysis, and Alternatives 3 and 4 would create measures for the collection of economic data sufficient to give fishery managers a better understanding of socioeconomic issues. Alternatives 3 and 4 would also retain, expand, and improve upon existing reporting requirements. Example FMP 4.2, while it would effectively eliminate the need for reporting requirements, would create fishery-specific data-collection measures for those fisheries authorized to occur. For further detail on this FMP component and its likely environmental consequences, see Appendix F-11.

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4.4 Summary of the Comparative Baseline

Chapter 3 of this document contains a comprehensive assessment of the human (physical, biological, and socioeconomic) environment potentially affected by the Alaska groundfish fisheries. For each of the resource categories used to analyze the impacts of the alternatives in this document, a comparative baseline has been developed. The baseline incorporates the state of the resource at a given point in time. In general, the baseline year is 2002 for physical and biological resources, and 2001 for socioeconomics. It is used to analyze the impacts of the alternatives.

The baseline does not represent a static 'snapshot' of the resource. Instead, it represents the trend of the resource, incorporating the past history of influences on the resource. The cumulative past effects of groundfish fishery activity, as well as effects external to the groundfish fishery such as other fishery impacts, human-induced impacts, and climatic events influencing the resource, all contribute to the state of the baseline condition.

In the table below, only those resource categories that were brought forward for alternatives impacts analysis are included. Some resource categories were identified in Chapter 3 as having in the past been impacted by the groundfish fisheries, but that interaction no longer occurs. More information on each resource category and the derivation of the baseline condition, can be accessed in the relevant section of Chapter 3.

The following is a list of tables containing information on resource categories and components:

Table number	Resource category	Components	Chapter 3 reference
4.4-1	Target groundfish species	Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) walleye pollock, BSAI and GOA Pacific cod, BSAI and GOA sablefish, BSAI and GOA Atka mackerel, BSAI yellowfin sole, GOA shallow water flatfish, BSAI rock sole, BSAI and GOA flathead sole, BSAI and GOA arrowtooth flounder, BSAI Greenland turbot, GOA deepwater flatfish, BSAI Alaska plaice, BSAI other flatfish, GOA rex sole, BSAI and GOA Pacific ocean perch, GOA thornyhead rockfish, BSAI and GOA northern rockfish, BSAI and GOA shortraker/rougheye rockfish, BSAI other rockfish, GOA slope rockfish, GOA pelagic shelf rockfish, GOA demersal shelf rockfish	3.5.1
4.4-2	Prohibited species	Pacific halibut, Pacific salmon and steelhead trout, Pacific herring, crab	3.5.2
4.4-3	Other species, forage fish species, non-specified species	Other species category Forage fish category Grenadier	3.5.3, 3.5.4, 3.5.5
4.4-4	Habitat	BSAI, GOA	3.6
4.4-5	Seabirds	Black-footed albatross, Laysan albatross, short-tailed albatross, northern fulmar, shearwaters, storm-petrels, cormorants, spectacled eider, Steller's eider, jaegers, gulls, kittiwakes, terns, murres, guillemots, murrelets, auklets, puffins	3.7

Table number	Resource category	Components	Chapter 3 reference
4.4-6	Marine mammals	Steller sea lion, northern fur seal, Pacific walrus, harbor seal, spotted seal, bearded seal, ringed seal, ribbon seal, northern elephant, sea otter, blue whale, fin whale, sei whale, minke whale, humpback whale, gray whale, northern right whale, bowhead whale, sperm whale, beaked whales (Baird's, Cuvier's and Stejneger's), Pacific white-sided dolphin, killer whale, beluga whale, harbor porpoise, Dall's porpoise	3.8
4.4-7	Socioeconomics	Harvesting and processing Sector (catcher vessels [CVs], catcher processors [CPs], Inshore processors and motherships) Regional socioeconomic profiles (population, processing ownership and activity, CV ownership and activity, tax revenue, employment and income) Community development quota (CDQ) allocations Subsistence (subsistence use of groundfish, subsistence use of Steller sea lions, salmon subsistence fisheries, indirect subsistence factors: income and joint production) Environmental justice Market channels and benefits to United States consumers (product quantity, product year-round availability, product quality, product diversity) Non-market goods (benefits derived from marine ecosystems and associated species)	3.9.2 3.9.3 3.9.4 3.9.5 3.9.6 3.9.7 3.9.8
4.4-8	Ecosystem	Forage fish availability, spatial/temporal concentration of fisheries, introduction of non-native species, removal of top predators, energy redirection, energy removal, species diversity, guild diversity, genetic diversity	3.10

4.5 Alternative 1 Analysis

FMP 1 models status quo management, which has the goal of maintaining sustainable fisheries, protecting threatened and endangered species, and protecting, conserving, and restoring living marine resource habitats through existing institutions and processes. This alternative is described in detail in Section 2.6.

4.5.1 Target Groundfish Species Analysis

This section examines the potential direct, indirect, and cumulative effects that the implementation of FMP 1 is expected to have on the target groundfish species. The impact analyses start with the baseline (2002) status of the BSAI and GOA target groundfish stocks described in Section 3.5.1, including past trends that are likely to persist into the foreseeable future. Then, a computer-based analytic model is used to project how specific characteristics of the target groundfish stocks would respond directly and indirectly to management actions under FMP 1. These projections from the model are the predicted direct and indirect effects (impacts) of FMP 1 on the target groundfish stocks. Section 4.1.5 describes the analytic model and explains how it is applied.

The model output for each target groundfish stock is defined in terms of collected data and calculated measures that are standards used by fisheries managers to regulate the number of fish removed from the sea so that the fisheries will be sustainable over the long-term. These data and measures include the fishing mortality rate (F), the overfishing level (OFL), total and spawning biomass levels (B), the minimum stock size threshold (MSST), maximum sustainable yield (MSY), mean age of the stock in years, and the sex ratio of the stock (number of males compared to number of females). As discussed in the following subsections, relevant data are not always available for all stocks. When data gaps prevent application of the model to a specific stock, the projected direct or indirect effect is evaluated as unknown.

Each target groundfish stock is modeled with respect to the following direct and indirect effects:

Direct/Indirect Effects

Fishing Mortality: This is the rate at which the stock is depleted by direct mortality imposed by removing the fish from the sea.

Change in Biomass Level: This is the change over time in the biomass of the stock, as measured in metric tons (mt). Two measures are used: total biomass, which is the estimated biomass of the entire stock, and spawning biomass, which is the estimated biomass of all of the spawning females in the stock.

Spatial/Temporal Concentration of Catch: This is the degree to which the fishery will concentrate in a particular geographic area during a particular period of time each season. This pattern in space and time can affect fishing mortality and can also influence habitat suitability for spawning, rearing, and feeding.

Habitat Suitability: This is the degree to which habitat has the right characteristics to support the target stock at one or more life-history stages (spawning, rearing of juveniles, availability of food at all stages, availability of refuge areas to allow escape from predators at all stages). Habitat suitability can be affected directly, for example by mechanical damage from bottom trawling, or influenced indirectly, for example by the gradual depletion of corals that provide hard substrate.

Prey Availability: This is the extent to which prey species are present in the environment and available as food to the target stock. Like habitat suitability, this measure can be affected directly, for example by the direct removal of prey species by the fishery, or indirectly, for example by a change in the structure of the food web.

To determine their probable significance, the projected direct and indirect effects in each of the impact categories listed above are evaluated against significance criteria. The criteria are designed to be relevant and meaningful in terms of the target groundfish stocks. Each significance criterion includes a threshold value above (or below) which the projected effect would be considered significant. Each criterion also includes a definition of what would constitute a beneficial (positive, +) or adverse (negative, -) effect. The possible evaluations are significant and beneficial (S+), insignificant (I), significant and adverse (S-), and unknown (U). Evaluations of conditionally significant (CS + or -) are not made for projected direct and indirect effects on target groundfish species, because the model can show only whether the significance threshold is or is not exceeded. The significance criteria used for the target groundfish stocks are presented in Appendix A, Table 4.1-1.

Each of the following subsections presents the model results and rationale for the expected direct and indirect effects of FMP 1 on the target groundfish stocks. The significance ratings for these potential direct and indirect effects are presented in Appendix A, Table 4.5-83. Following the direct and indirect effects discussions on each stock, the expected cumulative effects on that stock are evaluated and discussed. The evaluation of potential cumulative effects builds on the direct and indirect effects evaluations as a starting point, and then brings in persistent past effects as well as reasonably foreseeable future natural events and human activities external to fisheries management. The cumulative effects assessment method uses the same impact categories and significance criteria discussed above for direct and indirect effects. This method is described further in Section 4.1.4.

4.5.1.1 Pollock

Numerous fishery management actions have been implemented that affect the pollock fisheries in the EBS and GOA. These actions are described in more detail in Sections 3.5.1.1 and 3.5.1.15 of this Programmatic SEIS. Pollock is managed as separate stocks in the BSAI and GOA, and falls under Tier 1 in both the BSAI and GOA groundfish FMPs.

Direct/Indirect Effects of FMP 1

The following discussions describe the analysis of potential direct and indirect impacts of FMP 1 on EBS and GOA pollock. As summarized in Table 4.5-83, all direct and indirect effects of FMP 1 on pollock are expected to be insignificant, as defined by the criteria in Table 4.1-1.

Fishing Mortality

The estimated fishing mortality for the EBS pollock stock in 2002 is 0.187. Model projections show this fishing mortality will increase by about 30 percent and average 0.228 for the period 2003-2007 (Table H.4-1 of Appendix H). These values are below the $F_{35\%}$ level of 0.448 and the $F_{40\%}$ level of 0.342, which are taken as proxies for F_{ABC} and F_{OFL}, respectively. This pattern in fishing mortality is due to the fact that the projected catch is expected to come closer to the actual ABC in future years. The proportion of SPR conserved under

these mortality rates is 51 percent in 2003, decreasing to 48 percent by 2007; the average implied SPR rate of fishing from 2003-2007 is 49 percent. Fishing mortality for the Bogoslof and Aleutian Islands region is expected to remain at less than one percent under FMP 1 (Table H.4-2 of Appendix H). Because the projected changes are not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis, the effects of FMP 1 on fishing mortality for the EBS pollock stock are considered to be insignificant.

For the GOA, fishing mortality in 2002 is estimated at 0.174 with projections suggesting a decrease to 0.139 in 2003 followed by increases to 0.209 by 2007. The values for $F_{35\%}$ and $F_{40\%}$ are 0.350 and 0.294, respectively. The SPR rate in 2002 is estimated at 55 percent and averages about 56 percent for the period 2003-2007. This F pattern is due to the fact that under this FMP, the F_{ABC} is adjusted while the spawning stock is below $B_{40\%}$. Model projections for GOA fishing mortality are shown in Table H.4-23 of Appendix H. Because they are not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis, these changes in fishing mortality levels for GOA pollock are considered to be insignificant.

Change in Biomass Level

Total Biomass

Total biomass (ages 1 through 15+) of EBS pollock at the start of 2002 is estimated to be 12.97 million mt. Model projections of future total EBS pollock biomass are shown in Table H.4-1 of Appendix H. Under FMP 1, model projections indicate that EBS pollock biomass is expected to decrease to a value of about 11.3 million mt in 2004, then stabilize to about 11.6 million mt. The 2003-2007 average total biomass is projected to be 11.5 million mt. The direct effects of FMP 1 are considered insignificant, because the biomass levels estimated for 2003-2007 are expected to be above the biomass proxy value necessary to sustain maximum sustainable yield (B_{MSY}) and thus maintain the ability of the EBS stock to sustain itself above the MSST.

In the Aleutian Islands region, the assessments are based on trawl surveys that occur every other year. The most recent assessment indicates a biomass level of 175,000 mt. Given that under FMP 1 there is no directed fishing for pollock in this region (the exploitation level is quite low, less than 1 percent), the expectation is that the stock will remain stable or increase in the future. A similar pattern is expected for the Bogoslof Island pollock stock. For this reason, the direct effect of FMP 1 on the total biomass of the Aleutian Islands and Bogoslof Island pollock stocks is expected to be insignificant.

For GOA pollock, the age 2-10+ biomass is expected to increase under this FMP from a 2003 low of 800,000 mt to 1,210,000 mt by 2007. The average biomass over this period is expected to be 1,030,000 mt. This increase is anticipated primarily because recruitment is expected to improve from the recent series of relatively low levels. Model projections of future total GOA pollock biomass are shown in Table H.4-23 of Appendix H. The predicted direct effects of FMP 1 on GOA total pollock biomass are considered insignificant, because the biomass levels estimated for 2003-2007 are expected to maintain the ability of the GOA stock to sustain itself above the MSST.

Spawning Biomass

Female spawning biomass of EBS pollock in 2002 is estimated to be about 3.68 million mt. Model projections of future levels are shown in Table H.4-1 of Appendix H. Under FMP 1, projections indicate that EBS pollock spawning biomass will decrease to about 81 percent of the 2002 level by 2007. The projected

average for 2003-2007 is 3.08 million mt. Because this level of decrease in female spawning biomass would not prevent the EBS pollock stock from sustaining itself at or above the MSST, the direct effect of FMP 1 on EBS pollock spawning biomass is considered to be insignificant.

In the Aleutian Islands region, spawning biomass is monitored by biannual trawl surveys. In the Bogoslof Island region, spawning stock is monitored by echo-integration trawl surveys. Since under FMP 1 these areas are kept at bycatch-only levels, we expect the spawning stock size to remain stable or increase in these regions. For this reason, the direct effect of FMP 1 on the spawning biomass of these stocks is expected to be insignificant.

The 2002 GOA female spawning biomass is estimated at about 136,000 mt and is anticipated to increase steadily to 228,000 mt by 2007 under FMP 1. This is above the estimated B_{MSY} level of 210,000 mt although the average from 2003-2007 is 183,000 mt. Model projections of future levels are shown in Table H.4-23 of Appendix H. Because the estimated increase in female spawning biomass is expected to maintain the ability of the GOA pollock stock to sustain itself above the MSST, this effect is considered to be insignificant.

Spatial/Temporal Concentration of Catch

The harvest of EBS pollock occurs largely along the western edge of the EBS shelf during the summer and around the southern areas east of 170°W during the winter season (January 20-March). Under FMP 1, an average of 1.4 million mt of EBS pollock is projected to be harvested annually from 2003-2007. The Bogoslof and Aleutian Island concentration of fishing mortality is anticipated to remain unchanged over this projection period. Because the spatial/temporal concentration of the catch under FMP 1 would not change notably from existing conditions, there is no evidence to suggest that harvest concentrations would be sufficient to alter genetic sub-populations or reproductive success in ways that affect the ability of the EBS pollock stock to sustain itself at or above the MSST. Therefore, this potential effect is considered to be insignificant.

Under FMP 1, an average of 87,300 mt of GOA pollock is projected to be harvested annually during 2003-2007 with the largest catch expected to be 133,000 mt in 2007. As the density and quotas of pollock change during this period, the concentration of the pollock fishery may change from the 2002 pattern. However, there is no indication that under FMP 1, harvest concentrations would change sufficiently to alter genetic sub-populations or reproductive success in ways that affect the ability of the GOA pollock stock to sustain itself at or above the MSST. Therefore, the direct effect of FMP 1 on the spatial and temporal concentration of the catch is expected to be insignificant relative to baseline conditions.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Given the similarity of FMP 1 to the status quo, however, it is unlikely that future levels of habitat disturbance would lead to a detectable change in spawning or rearing success sufficient to jeopardize the ability of the stocks to sustain themselves at or above the MSST. Therefore, the direct and indirect effects of FMP 1 on EBS and GOA pollock habitat suitability are expected to be insignificant.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. An evaluation of potential trophic interactions is presented in Section 3.10. Because of its similarity to the status quo, however, it is unlikely that FMP 1 would introduce changes in predator-prey interactions sufficient to affect the ability of pollock stocks to maintain themselves at or above the MSST. Therefore, the direct and indirect effects of FMP 1 on EBS and GOA pollock prey availability are expected to be insignificant.

Summary of Direct and Indirect Effects of FMP 1 on Pollock

The impact assessments discussed above indicate that the direct and indirect effects of FMP 1 on BSAI and GOA pollock would be insignificant for all of the effects categories (see Appendix A, Table 4.5-83). In addition, the fact that pollock would be fished at less than the OFL and above the MSST provides a separate rationale for considering the direct and indirect effects under FMP 1 to be insignificant. Fishing rates under this FMP would be well within accepted scientific standards, based on studies of population dynamics and estimates of natural variations in recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity. Based on extended 20-year projections (with the same model assumptions as used in the base 2003-2007 period), both the EBS and GOA pollock are expected to stabilize with catches lower than the expected long-term F_{ABC} catch levels and Bs above the B_{MSY} levels.

Status Determination from Modeling

Modeling projections for 2003-2007 indicate that under FMP 1, the future status of EBS and GOA pollock stocks would be as follows for key indicators.

Stock Size Relative to MSST

Under FMP 1, the ABC is set at a lower level than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of EBS pollock are below the ABC and OFL levels in all years. The EBS pollock are above their respective MSST in the year 2002 and in all subsequent projection years.

For FMP 1, GOA pollock spawning biomass is below the B_{MSY} (taken as $B_{35\%}$) in 2002 and remains below this level until 2007. However, based on 10-year status determinations projections, the stock is above the MSST for all years 2003-2007.

Age and Size Composition

Under FMP 1, the mean age of the EBS pollock stock at the end of 2007, as computed in model projections, is 2.53 years. This compares with a mean age in an equilibrium unfished stock of 3.16 years. For GOA pollock the 2007 value is 3.00 years compared with an unfished estimate of 3.60 years (note that the GOA pollock assessment is modeled from age 2-10+ while the EBS pollock is modeled from age 1-15). Model projections of EBS and GOA pollock age and size compositions are shown in Tables H.4-1 and H.4-23 of Appendix H.

Sex Ratio

In the models, the sex ratio of GOA and BSAI pollock are assumed to be 50:50. However, observer data and information from surveys are routinely collected and used to monitor the sex ratios of these stocks. Based on these data, it is unlikely that the sex ratio would be affected under FMP 1.

Cumulative Effects of FMP 1

External effects and the resultant cumulative effects associated with FMP 1 are shown in Tables 4.5-1 and 4.5-2. For further information regarding persistent past effects listed below in the text and in the tables, see Sections 3.5.1.1 and 3.5.1.15.

EBS Pollock

Mortality

- **Direct/Indirect Effects**. As described above under direct/indirect effects, the effect of fishing mortality on the EBS pollock stock is insignificant under FMP 1.

- **Persistent Past Effects.** The past effects of the foreign, Joint Venture (JV), and domestic fisheries are not expected for the EBS pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the BSAI pollock populations (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Removals of pollock occur in the Russian pollock fishery, and the catch is not accounted for in the annual harvest rates set for the U.S. fishery. Therefore, the removals can be considered a potential adverse effect on fishing mortality. Catch and bycatch of pollock in the State of Alaska pollock fisheries are not contributing factors since catch is accounted for. Marine pollution is also identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** The cumulative effects under FMP 1 is identified for mortality of EBS pollock, but the effect is judged to be insignificant. Pollock are fished at less than the OFL and are above the minimum stock size threshold (MSST). The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** As described above in Section 4.5.1.1, change in biomass of the EBS pollock stock is expected to be insignificant under FMP 1.

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.1), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to removals in the Russian and State of Alaska pollock fisheries. However, the effects of any future removals are expected to be negligible and are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to pollock mortality, and therefore would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect on the change in biomass is identified; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1, the harvest of EBS pollock will continue to occur mostly along the western edge of the EBS shelf during the summer and around the southern areas east of 170°W longitude during the period (January 20 - March). Under these considerations, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.1) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had a beneficial effect on pollock recruitment by reducing the adult pollock biomass, lingering beneficial effects are identified for change in reproductive success. In addition, past commercial whaling and sealing also removed large predators of pollock, adding to the potential for reproductive success of the stock. Lingering past effects are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** The Russian and State of Alaska pollock fisheries have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. On the other hand, removals in these fisheries could have a potential beneficial effect on pollock recruitment by reducing the adult pollock biomass. Cannibalism-related declines in pollock recruitment have been observed at high pollock spawning biomasses (see Section 3.5.1.1). Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see above discussion of direct/indirect effects). However, it is determined that FMP 1 would have insignificant effects on pollock prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of pollock prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Past effects of climate changes and regime shifts on pollock prey species could have potential beneficial or potential adverse effects. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.5-1 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey species is not expected to decrease prey availability such that the pollock stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see above discussion of direct/indirect effects). However, it is determined that FMP 1 would have insignificant effects on pollock habitat suitability.

- **Persistent Past Effects.** Past effects identified for EBS pollock stocks include past foreign, JV, and domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.1). Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the EBS. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external are possible from the Russian and State of Alaska fisheries, since any of these may impact bottom habitat through use of fishing

gear. Impacts on habitat from climate changes and regime shifts on the EBS pollock stock are unknown, although a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, that effect on the EBS pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is jeopardized.

GOA Pollock

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA pollock stock is insignificant under FMP 1 (see Section 4.5.1.1 Direct/Indirect Effects discussion).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, State of Alaska, and bait fisheries are not expected for the GOA pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the GOA pollock populations (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Catch and bycatch of pollock in the State of Alaska pollock fisheries, and State of Alaska shrimp fisheries, climate changes, and regime shifts are not considered to be contributors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. However, marine pollution could have a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized.

- **Cumulative Effects.** A cumulative effect under FMP 1 is identified for mortality of GOA pollock, but the effect is judged to be insignificant. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA pollock stock is expected to be insignificant under FMP 1 (see Section 4.5.1.1).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.1), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to removals in the State of Alaska pollock fisheries. However, these removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to pollock mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified; however, the combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 in the GOA, impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population (see Section 4.5.1.1 Direct/Indirect Effects discussion).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.1) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** While there are potential adverse effects due to the State of Alaska pollock fisheries, and the State of Alaska shrimp fishery these fisheries are not sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see Section 4.5.1.1 Direct/Indirect Effects discussion). However, it is determined that FMP 1 would have insignificant effects on pollock prey availability.

- **Persistent Past Effects.** Lingering population level effects are not expected on these species from past foreign, state, and domestic fisheries catch and bycatch of pollock prey species, the effects of

the *Exxon Valdez* Oil Spill (EVOS). However, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** As described for BSAI pollock, climate changes and regime shifts could have beneficial or adverse effects depending on water temperature changes. Marine pollution is a potential contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.5-2 are determined have potential adverse effects due to the removal of prey species as catch and bycatch. However, they are not likely to have population level effects on pollock.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the combination of internal and external removals of prey is not expected to decrease prey availability such that the pollock stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that FMP 1 would have insignificant effects on pollock habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA pollock stocks include past foreign, JV, State of Alaska, and domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.1). Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska Pollock and Shrimp fisheries, since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA pollock stock are unknown, although a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, that effect on the EBS pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is jeopardized.

4.5.1.2 Pacific Cod

Numerous fishery management actions have been implemented that affect the Pacific cod fisheries in the BSAI and GOA. These actions are described in more detail in Sections 3.5.1.2 and 3.5.1.16 of this Programmatic SEIS. Pacific cod is managed as separate stocks in the BSAI and GOA, both of which are managed under Tier 3a.

Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI and GOA Pacific cod. All direct and indirect effects of FMP 1 on Pacific cod are expected to be insignificant. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The F imposed on the BSAI Pacific cod stock in 2002 was estimated to be 0.228. Model projections of future BSAI Fs are shown in Table H.4-3 of Appendix H. Under FMP 1, model projections indicate that BSAI fishing mortality will increase to a value of 0.286 in 2003, decrease to a value of 0.269 in 2005, increase to a value of 0.274 in 2006,and then decrease to a value of 0.267 in 2007, with a 2003-2007 average of 0.275. These values are well below the F_{MSY} proxy value of 0.409, which is the rate associated with the overfishing level for stocks above $B_{40\%}$. The projected changes in the F are considered to be insignificant, because they would not jeopardize the capacity of the stock to produce MSY on a continuing basis.

The F imposed on the GOA Pacific cod stock in 2002 was estimated to be 0.255. Model projections of future GOA Fs are shown in Table H.4-24 of Appendix H. Under FMP 1, model projections indicate that GOA fishing mortality is expected to decrease steadily to a value of 0.204 in 2007, with a 2003-2007 average of 0.211. These values are well below the F_{MSY} proxy value of 0.421, which is the rate associated with the overfishing level for stocks above $B_{40\%}$. These projected changes in the F are also considered to be insignificant, because they would not jeopardize the capacity of the GOA stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

Total (ages 1 through 12+) biomass of BSAI Pacific cod at the start of 2002 is estimated to be 1,933,000 mt. Model projections of future total BSAI biomasses are shown in Table H.4-3 of Appendix H. Under FMP 1, model projections indicate that total BSAI biomass is expected to increase steadily to a value of 2,118,000 mt in 2007, with a 2003-2007 average value of 2,086,000 mt. This projected increase is considered to be insignificant, because it would tend toward a level that would maintain the existing ability of the stock to sustain itself above the MSST.

Total (ages 1 through 12+) biomass of GOA Pacific cod at the start of 2002 is estimated to be 568,000 mt. Model projections of future total GOA biomasses are shown in Table H.4-24 of Appendix H. Under FMP 1, model projections indicate that total GOA biomass is expected to increase steadily to a value of 713,000 mt

in 2007, with a 2003-2007 average value of 645,000 mt. This projected increase is considered to be insignificant, because it would tend toward a level that would maintain the existing ability of the stock to sustain itself above the MSST.

Spawning Biomass

Spawning biomass of female BSAI Pacific cod at the start of 2002 was estimated to be 404,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-3 of Appendix H. Under FMP 1, model projections indicate that BSAI spawning biomass is expected to decrease to a value of 403,000 mt in 2003, then increase to a value of 445,000 mt in 2006, then decrease to a value of 443,000 mt in 2007, with a 2003-2007 average value of 430,000 mt. Projected spawning biomass never dips below the B_{MSY} proxy value of 361,000 mt for the years 2003-2007. The projected fluctuations in B are considered to be insignificant, because they would tend toward levels that would maintain the existing ability of the stock to sustain itself above the MSST.

Spawning biomass of female GOA Pacific cod at the start of 2002 was estimated to be 97,900 mt. Model projections of future GOA spawning biomasses are shown in Table H.4-24 of Appendix H. Under FMP 1, model projections indicate that GOA spawning biomass is expected to decrease to a value of 86,400 mt in 2004, then increase to a value of 98,800 mt in 2007, with a 2003-2007 average value of 91,000 mt. Projected spawning biomass never dips below the B_{MSY} proxy value of 79,000 mt for the years 2003-2007. The projected fluctuations in B are considered to be insignificant, because they would tend toward levels that would maintain the existing ability of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

Under FMP 1, it is likely that fishing for BSAI and GOA Pacific cod would tend, to some extent, to be concentrated in space and time so as to coincide with concentrations of spawning fish. Evaluating the effects of such concentrations of fishing mortality is problematic for two reasons: 1) Such concentrations of fishing mortality have already been in place for many years. Although the stocks currently appear to be healthy despite such concentrations, the absence of a "control" treatment makes it difficult to determine which population characteristics are attributable specifically to the existing spatial/temporal concentrations of fishing mortality. 2) Pacific cod undertake large migrations, and a high degree of genetic mixing appears to exist. In comparison to a sedentary species with readily identifiable genetic subunits, this means that the effects of spatial/temporal concentrations of fishing effort on Pacific cod are probably diluted to some extent, and also that their evaluation involves a larger number of difficult-to-estimate parameters. However, there is no indication that under FMP 1, harvest concentrations would change sufficiently to alter genetic sub-populations or reproductive success in ways that affect the ability of the GOA pollock stock to sustain itself at or above the MSST. Therefore, the direct effect of FMP 1 on the spatial and temporal concentration of the catch is expected to be insignificant relative to baseline conditions.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Because fishing practices under FMP 1 would be similar to the status quo, however, it is unlikely that future levels of habitat disturbance would lead to a detectable change in spawning or rearing success sufficient to jeopardize the ability of the stock to sustain itself at or above the

MSST. Therefore, the direct and indirect effects of FMP 1 on Pacific cod habitat suitability are expected to be insignificant.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Because of its similarity to the status quo, however, it seems unlikely that FMP 1 would introduce changes in predator-prey interactions sufficient to affect the ability of the Pacific cod stock to maintain itself at or above the MSST. Therefore, the direct and indirect effects of FMP 1 on prey availability for Pacific cod are expected to be insignificant.

Summary of Direct and Indirect Effects of FMP 1 on Pacific Cod

The criteria used to rate the significance of impacts of FMP 1 on the BSAI and GOA stocks of Pacific cod are identical to those used for the other groundfish stocks and are described in Appendix A, Table 4.1-1. Appendix A, Table 4.5-83 summarizes the expected effects of FMP 1 on Pacific cod. The rating of conditionally significant (either beneficial or adverse) is not applicable to any of the direct or indirect effects in this analysis, because the analytic model yields projections that can be classified only as significant (beneficial or adverse), insignificant, or unknown.

For the BSAI and GOA Pacific cod stocks, the impact of FMP 1 on fishing mortality and biomass is rated as insignificant, because the projection model indicates that fishing mortality would be less than the overfishing level and that biomass would be above the MSST throughout the period 2003-2007.

Because the existing spatial/temporal concentration of the catch does not appear to have led to changes in the genetic structure of the BSAI or GOA Pacific cod populations that materially affect either stock's ability to maintain itself at or above the MSST, and because the impacts of spatial/temporal concentration on genetic structure under FMP 1 are expected to be no greater than those of the existing concentration, the magnitude of this effect is rated as insignificant for both stocks.

Similarly, because the existing spatial/temporal concentration of the catch does not appear to have led to changes in the reproductive success of the BSAI or GOA Pacific cod populations that materially affect either stock's ability to maintain itself at or above the MSST, and because the impacts of spatial/temporal concentration on reproductive success under FMP 1 are expected to be no greater than those of the existing concentration, the magnitude of this effect is rated as insignificant for both stocks.

Because the existing level of groundfish harvest does not appear to have led to changes in prey availability for the BSAI or GOA Pacific cod populations that materially affect either stock's ability to maintain itself at or above the MSST, and because the level of groundfish harvest under FMP 1 is expected to be no greater than the existing level, the magnitude of this effect is rated as insignificant for both stocks.

Finally, because the existing level of habitat disturbance does not appear to have led to changes in spawning or rearing success in the BSAI or GOA Pacific cod populations that materially affect either stock's ability to maintain itself at or above the MSST, and because the level of habitat disturbance under FMP 1 is expected to be no greater than the existing level, the magnitude of this effect is rated as insignificant for both stocks.

Relationship to Comparative Baseline

The comparative baselines for BSAI and GOA Pacific cod are identical: neither stock is overfished, the biomass of each stock is below $B_{40\%}$ and has been decreasing for the last few years, and all catch and bycatch are accounted for in the management of both stocks. Under FMP 1, both stocks are projected to remain above MSST throughout the period 2003-2007; the biomass of the BSAI stock is projected to be above $B_{40\%}$ throughout the period 2003-2007 while the biomass of the GOA stock is projected to be below $B_{40\%}$ in 2003-2005, the biomass of each stock is expected to show an overall increase during the period 2003-2007 and beyond, and all catch and bycatch would continue to be accounted for in the management of both stocks.

Status Determination from Modeling

Modeling projections for 2003-2007 suggest that under FMP 1, the future status of the BSAI and GOA Pacific cod stocks would be as follows for key indicators.

Stock Size Relative to MSST

Model projections of future catches of BSAI and GOA Pacific cod are below their respective overfishing levels in all years under FMP 1 (Tables H.4-3 and H.4-24 of Appendix H). The BSAI and GOA Pacific cod stocks are projected to be above $B_{35\%}$ and therefore above their respective MSSTs in every year throughout the period 2003-2007.

Age and Size Composition

Under FMP 1, the projected mean age of the BSAI Pacific cod stock in 2008 is 2.8 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.2 years.

Under FMP 1, the projected mean age of the GOA Pacific cod stock in 2008 is 2.8 years. This compares with a mean age in the equilibrium unfished GOA stock of 3.2 years.

Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Pacific cod in both the BSAI and GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

External effects and the resultant cumulative effects associated with FMP 1 are depicted on Tables 4.5-3 and 4.5-4. For further information regarding persistent past effects listed below in the text and in the tables, see the past/present effects analysis section of Sections 3.5.1.2 and 3.5.1.16.

BSAI Pacific Cod

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI and Pacific cod stock is insignificant under FMP 1 (see the direct/indirect discussion above).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the BSAI Pacific cod stock. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see above).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Pacific cod are predicted to continue in the International Pacific Halibut Commission (IPHC) longline fishery, State of Alaska crab fishery and subsistence/personal use fishery in the BSAI, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels and do not add additional fishing mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect under FMP 1 is identified for mortality of BSAI Pacific cod, but the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** As described in Section 4.5.1.2 direct/indirect effects, change in biomass of the BSAI Pacific cod stock is expected to be insignificant under FMP 1.

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.2), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries and bycatch and removals in the subsistence/ personal use fishery in the BSAI. However, these removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the Pacific cod biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population. Pacific cod are migratory species and a large degree of genetic mixing appears to exist. This likely means that the spatial/temporal concentration of fishing effort is diluted to some extent.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.2) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline and State of Alaska crab fisheries, and subsistence use in the BSAI, have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that FMP 1 would have insignificant effects on Pacific cod prey availability (see the direct/indirect effects discussion).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and state fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Pacific cod prey species are unknown; however, a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown in Table 4.5-3 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effects are insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific cod stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see above). Because the level of habitat disturbance under FMP 1 is expected to be no greater than the existing level, the effect is rated as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI Pacific cod stock include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline fishery, and climate changes and regime shifts (see Section 3.5.1.2). Previous Pacific cod fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the BSAI Pacific cod stock are unknown, although a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, the combination of internal and external impacts on habitat is not expected to jeopardize the Pacific cod stock such that it is unable to sustain itself at or above MSST.

GOA Pacific Cod

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific cod stock is insignificant under FMP 1 (see direct/indirect effects discussion above).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the GOA Pacific cod stock. Additionally, the State of Alaska groundfish fishery contributed to past removals in the GOA. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see persistent past effects above).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery, subsistence/personal use fishery, and in the State of Alaska groundfish fisheries in the GOA, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect under FMP 1 is identified for mortality of GOA Pacific cod, but the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific cod stock is expected to be insignificant under FMP 1 (see Section 4.5.1.2 direct/indirect effects discussion).

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.2), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/personal use fishery, and in the State of Alaska groundfish fisheries. However, these removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the

point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the Pacific cod biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population. Pacific cod are migratory species and a large degree of genetic mixing appears to exist. This likely means that the spatial/temporal concentration of fishing effort is diluted to some extent.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.2) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment particularly in the GOA where the state groundfish fishery is very localized, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline and State of Alaska crab fisheries, subsistence use, and State of Alaska groundfish fisheries have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see direct/indirect effects discussion). However, it is determined that FMP 1 would have insignificant effects on Pacific cod prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and state fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Pacific cod prey species are unknown; however, a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.5-4 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific cod stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see Section 4.5.1.2 direct/indirect effects discussion above). Because the level of habitat disturbance under FMP 1 is expected to be no greater than the existing level, the effect is rated as insignificant.

- **Persistent Past Effects.** Past effects identified for GOA Pacific cod include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline fishery, and climate changes and regime shifts (see Section 3.5.1.2). Additionally, the State of Alaska groundfish fishery contributed to habitat impacts in the GOA. Past fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA Pacific cod stock are unknown, although a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, the combination of internal and external impacts on habitat is not expected to jeopardize the ability of the Pacific cod stock to sustain itself at or above MSST.

4.5.1.3 Sablefish

This section provides the direct, indirect, and cumulative effects analyses for sablefish under FMP 1. Sablefish are managed as one stock in the BSAI and GOA under Tier 3b; therefore, BSAI and GOA areas are discussed together in this section.

Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on sablefish. All direct and indirect effects of FMP 1 on sablefish are expected to be insignificant. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1. Sections 3.5.1.3 and 3.5.1.17 provide additional information on the past/present effects analysis for BSAI and GOA sablefish.

Fishing Mortality

Under FMP 1, the fishing mortalities imposed on the sablefish stock are well below the F_{MSY} proxy value of 0.14 which is the rate associated with the OFL. Model projections of future BSAI and GOA fishing mortalities are shown in Tables H.4-11 and H.4-30 of Appendix H. The projected changes in the F are considered to be insignificant, because they would not jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

FMP 1 is projected to have an insignificant impact on total biomass (age 2-31+) compared to the baseline. FMP 1 assumptions are intended to replicate baseline conditions, in which biomass tends toward levels that maintain the ability of the BSAI and GOA sablefish stocks to sustain themselves above the MSST. Total biomass increases from 2002-2007 under FMP 1 because long-term average recruitment (1977-present) is used to project biomass and is higher than most of the recent recruitments. Model projections of future BSAI and GOA total biomasses are shown in Tables H.4-11 and H.4-30 of Appendix H.

Spawning Biomass

FMP 1 is projected to have an insignificant impact on spawning biomass compared to the baseline. FMP 1 assumptions are intended to replicate baseline conditions, in which biomass tends toward levels that maintain the ability of the BSAI and GOA sablefish stocks to sustain themselves above the MSST. Spawning biomass decreases from 2002-2007 under FMP 1 because the strong 1997 year-class is decreasing in abundance and is the only strong year-class among recent recruitments.

Spawning biomass is projected to decrease from 2002-2007 while total biomass is projected to increase during the same interval. Total biomass includes ages 2-30+ while spawning biomass includes ages 6.5-30+ (initial age is average age of first spawning for females) so that spawning biomass trends due to changing recruitment lag total biomass trends. Spawning biomass will likely increase for a longer projection. Model

projections of future BSAI and GOA spawning biomasses are shown in Tables H.4-11 and H.4-30 of Appendix H.

Spatial/Temporal Concentration of Catch

Sablefish fishing is concentrated along the upper continental slope and deepwater gullies. FMP 1 is projected to have an insignificant impact on the spatial/temporal concentration of fishing mortality compared to the baseline. FMP 1 assumptions are intended to replicate baseline conditions.

Habitat Suitability

Because fishing practices under FMP 1 would be similar baseline conditions, it is unlikely that future levels of habitat disturbance would lead to a detectable change in spawning or rearing success sufficient to jeopardize the ability of the BSAI and GOA sablefish stocks to sustain themselves at or above the MSST. Therefore, the direct and indirect effects of FMP 1 on sablefish habitat suitability are expected to be insignificant.

Prey Availability

It is unlikely that FMP 1 would introduce changes in predator-prey interactions sufficient to affect the ability of the BSAI and GOA sablefish stocks to maintain themselves at or above the MSST, because status quo fishing practices would continue under this FMP. Therefore, the direct and indirect effects of FMP 1 on prey availability for sablefish are expected to be insignificant.

Summary of Direct and Indirect Effects of FMP 1 on Sablefish

All direct and indirect effects are found to be insignificant for sablefish under FMP 1.

Status Determination from Modeling

Modeling projections for 2003-2007 suggest that under FMP 1, the future status of EBS and GOA sablefish stocks would be as follows for key indicators.

Catch Relative to ABC

FMP 1 is projected to have an insignificant impact on average sablefish yield compared to the baseline. Yields similar to current levels are projected because FMP 1 assumptions are intended to replicate baseline conditions. Under FMP 1, therefore, sablefish would not be overfished or approach an overfished condition.

Age and Size Composition

FMP 1 is projected to have an insignificant impact on sablefish mean age relative to the baseline. The mean ages actually observed in 2008 (as opposed to projections of mean ages) will be driven largely by incoming recruitment strengths during the intervening years.

BSAI mean age likely is overestimated. The model assumes that the lower exploitation rate for the BSAI compared to the GOA will translate into greater mean age for the BSAI. However, sablefish migration is substantial enough to erase the effects of differential exploitation rates between the BSAI and GOA. The mean age for the GOA best represents the mean age for the BSAI/GOA because sablefish abundance is much greater for the GOA.

Sex Ratio

The sex ratio of the adult population is 40 males: 60 females, based on sex ratio data collected during sablefish longline surveys. This FMP probably would have no significant effect on the sex ratio relative to the baseline.

Cumulative Effects of FMP 1

External effects and the resultant cumulative effects associated with FMP 1 are shown in Table 4.5-5.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the sablefish stock is insignificant under FMP 1 (see Section 4.5.1.3 direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska groundfish fisheries are identified for sablefish. Large removals of sablefish occurred, particularly in the JV, and domestic fisheries. Catches that were under-reported during the late 1980s may have contributed to abundance declines in the 1990s. (see Section 3.5.1.3).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of sablefish are predicted to continue in the IPHC longline and State of Alaska groundfish fisheries, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels and do not add additional fishing mortality. Due the highly migratory nature, Canadian fisheries fishing within Canadian waters could be harvesting sablefish considered to be part of the GOA population. These removals are not accounted for in the TAC setting process and can be considered as having a potential adverse contribution to the cumulative case. Likewise, marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality sufficient to jeopardize the capacity of the stock to produce MSY on a continuing basis. Climate changes and regime shifts are not identified as being contributors to direct sablefish mortality.

- **Cumulative Effects.** A cumulative effect under FMP 1 is identified for mortality of sablefish, but the effect is judged to be insignificant. Sablefish are fished at less than the OFL and all catch and bycatch are accounted for (with the exception of any fish taken in Canadian waters) in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the sablefish stock is expected to be insignificant under FMP 1 (see Section 4.5.1.3 direct/indirect Effects discussion).

- **Persistent Past Effects.** While past large removals of sablefish and other past effects on biomass have been identified (see Section 3.5.1.3), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to catch and bycatch in the IPHC longline and State of Alaska groundfish fisheries, and in the Canadian fisheries. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to sablefish mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect on the change in biomass is identified; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the sablefish biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch
- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population. Sablefish fishing is concentrated along the upper continental slope and deepwater gullies. FMP 1 is projected to have an insignificant impact on the spatial/temporal concentration of fishing mortality compared to the baseline. FMP 1 assumptions are intended to replicate baseline conditions.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure or reproductive success. While spatial/temporal concentration of catch occurred in the state directed sablefish fisheries, there are no lingering effects due to the migratory nature of the fish (see Section 3.5.1.3).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline, State of Alaska groundfish, and Canadian fisheries all have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population or affect recruitment. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not

expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on sablefish prey availability.

- **Persistent Past Effects.** While lingering population level effects from catch and bycatch of sablefish prey species in past foreign and domestic and state fisheries are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on sablefish prey species (see Section 3.5.1.3).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on sablefish prey species are unknown; however, a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment (see Section 3.5.1.3). Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.5-5 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the sablefish stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that the FMP would have insignificant effects on sablefish habitat suitability.

- **Persistent Past Effects.** Past effects identified for sablefish include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline fishery, and climate changes and regime shifts (see Section 3.5.1.3). Past fishing for sablefish in the past fisheries likely disrupted habitat in areas of the GOA and possibly the BSAI. It is possible that some of these areas have not recovered (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the sablefish stock are unknown, although a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been

identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, those effects on the sablefish stock are insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the sablefish stock to sustain itself at or above MSST is jeopardized.

4.5.1.4 Atka Mackerel

Numerous fishery management actions have been implemented that affect the Atka mackerel fisheries in the BSAI and GOA. These actions are described in more detail in Sections 3.5.1.4 and 3.5.1.18 of this Programmatic SEIS. Atka mackerel is managed as separate stocks in the BSAI and GOA; in the BSAI it falls under Tier 3a of the ABC and OFL definitions. However, in the GOA this target species is managed under Tier 6.

Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI and GOA Atka mackerel. All direct and indirect effects of FMP 1 on BSAI Atka mackerel are expected to be insignificant. The potential effects on the GOA stock are unknown. Significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Model projections of future BSAI Atka mackerel catch and biomass levels under FMP 1 assume the maximum permissible F according to Amendment 56 ABC/OFL definitions. Currently, BSAI Atka mackerel are harvested at a more conservative rate than the maximum allowable, but the rates have varied as set by the NPFMC. Given the difficulty in predicting the future ABC levels to be set by the NPFMC, the projections assume the default Amendment 56 values. Therefore, under FMP 1, projections may suggest higher than expected catches and lower than expected biomass levels, at least in the very short-term.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown. Age-structured models were not available for evaluation of impacts for the GOA; therefore, model projections of future biomass levels were not produced.

Fishing Mortality

The average expected yield for BSAI Atka mackerel during the period 2003-2007 is 62,700 mt (Table H.4-17 of Appendix H). The catch and ABC values, which are nearly equivalent in the projections, are expected to decrease through 2006. The average fishing mortality imposed on the BSAI Atka mackerel stock in 2002 is 0.251. Model projections show this value will increase to 0.436 in 2004, then decrease in 2005 and increase to 0.401 in 2007. Overall, the projections show a 60 percent increase in the average fishing mortality from 2002 to 2007. These values are well below the F_{MSY} proxy ($F_{35\%}$) value of 0.564, which is the rate associated with the OFL. Therefore, the projected Fs for BSAI Atka mackerel under FMP 1 are considered to be insignificant, because they would not jeopardize the capacity of the stocks to produce MSY on a continuing basis.

The current GOA ABC and TAC level is 600 mt. This low level of TAC is intended to preclude a directed fishery and only provide for bycatch in other fisheries. This harvest strategy has been applied to GOA Atka mackerel since 1997 as a conservative measure to accommodate the lack of a reliable current estimate of biomass, and to recognize that GOA Atka mackerel may be particularly vulnerable to fishing pressure because of its patchy distribution and sporadic recruitment patterns (Lowe *et al.* 2002).

Projections of GOA Atka mackerel under FMP 1 indicate that catches will likely average 100 mt through 2007 (Table H.4-38 of Appendix H). Annual changes in the GOA Atka mackerel catches reflect shifts in catches of other species which catch Atka mackerel as bycatch (e.g. Pacific ocean perch, pollock, northern rockfish, and Pacific cod). Because data on which to establish a reliable current estimate of biomass for GOA Atka mackerel are lacking, the effects of fishing mortality on Atka mackerel under FMP 1 are unknown.

Change in Biomass Level

Total Biomass

Total (ages 1-15+) biomass of BSAI Atka mackerel at the start of 2002 is estimated to be 480,000 mt. Model projections of future total BSAI total biomasses are shown in Table H.4-17 of Appendix H. Under FMP 1, model projections indicate that total BSAI Atka mackerel is expected to decline to a value of 415,000 mt by 2005, then increase to a value of 442,000 mt by 2007, with a 2003-2007 average value of 435,000 mt. Overall, the projections show an 8 percent decrease in total biomass from 2002 to 2007 under FMP 1. This projected decrease is considered to be insignificant, because total Atka mackerel biomass in the BSAI would stay within a range that would maintain the existing ability of the stock to sustain itself above the MSST. Potential effects of FMP 1 on GOA Atka mackerel total biomass are unknown, because reliable estimates of the current total biomass are not available to support modeling.

Spawning Biomass

Spawning biomass of female BSAI Atka mackerel at the start of 2002 is estimated at 118,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-17 of Appendix H. Under FMP 1, model projections indicate that BSAI spawning biomass is expected to decline to a value of 78,500 mt by 2005, then increase to a value of 88,000 mt by 2007, with a 2003-2007 average value of 88,900 mt. Overall, the projections show about a 26 percent decrease in female spawning biomass from 2002 to 2007 under FMP 1. Projected spawning biomass exceeds the B_{MSY} proxy value ($B_{35\%}$) of 77,800 mt for the projection years (2003-2007). Although the BSAI Atka mackerel spawning biomass is projected to decline, it would stay within a range that would maintain the existing ability of the stock to sustain itself above the MSST. Therefore, this potential effect under FMP 1 is considered to be insignificant. Potential effects of FMP 1 on GOA Atka mackerel spawning biomass are unknown, because reliable estimates of the current spawning biomass are not available to support modeling.

Spatial/Temporal Concentration of Catch

Under FMP 1, the current network of spatial/temporal closed areas would remain in place. The closures designated in the Steller sea lion protection measures would probably have the largest impact relative to Atka mackerel.

The directed fishery for Atka mackerel is prosecuted by catcher processor bottom trawlers. The patterns of the fishery generally reflect the behavior of the species in that the fishery is highly localized, occurring in the same few locations each year, at depths that typically range between 100 and 200 m. The localized pattern of fishing for Atka mackerel apparently does not affect fishing success from one year to the next since local populations in the Aleutians appear to be replenished by immigration and recruitment. In addition, management measures are in place which have the effect of spreading out the harvest in time and space. The overall BSAI TAC is allocated to three management areas (Western, Central, and Bering Sea/Eastern Aleutians). The regional TACs are further allocated to two seasons, and there are limits to the amount of catch that can be taken inside of Steller sea lion critical habitat. Because Steller sea lion critical habitat overlaps significantly with Atka mackerel habitat, these measures provide protection to Atka mackerel by reducing the risk of localized depletion through effort limitations and reductions. The temporal/spatial concentration of the catch under FMP 1 does not appear to affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST. Under FMP 1, therefore, the spatial and temporal pattern of catch concentration would have an insignificant effect on BSAI Atka mackerel relative to the baseline.

Because population data are lacking on the GOA Atka mackerel stock, its MSST is unknown. Therefore, the potential effects of the spatial and temporal pattern of catch on this stock under FMP 1 are unknown.

Habitat Suitability

Because Steller sea lion critical habitat overlaps significantly with BSAI Atka mackerel habitat, Steller sea lion protection measures may provide habitat protection for Atka mackerel through effort limitations and reductions. The level of habitat disturbance caused by the fishery under FMP 1 does not appear likely to affect the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST. Therefore, impacts on habitat suitability for BSAI Atka mackerel would be insignificant under FMP 1. It is not known what effect implementation of FMP 1 would have on habitat suitability for GOA Atka mackerel, although fishing practices would be similar to those under the status quo.

Prey Availability

The trophic interactions of Atka mackerel are governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. In a study conducted by Yang (1996), more than 90 percent of the total stomach contents weight of Atka mackerel in the study was made up of invertebrates, with less than 10 percent made up of fish. The current levels and distribution of harvest do not appear to affect prey availability in ways that impair the ability of the stock to maintain itself above its MSST. Therefore, it is likely that potential effects of FMP 1 on prey availability for BSAI and GOA Atka mackerel would be insignificant.

Summary of Direct and Indirect Effects of FMP 1 on Atka Mackerel

The criteria used to estimate the significance of potential effects of the FMPs on the BSAI and GOA stocks of Atka mackerel are outlined in Section 4.1.1.1. The expected direct and indirect effects of FMP 1 on BSAI and GOA Atka mackerel are summarized in Appendix A, Table 4.5-83. Potential direct and indirect impacts

of FMP 1 on the BSAI and GOA Atka mackerel stocks are rated as either insignificant or unknown. The ratings of conditionally significant (either beneficial or adverse) are not applicable in this analysis, as the model projections could yield only results that were deemed significant (beneficial or adverse), insignificant, or unknown.

The ratings use the overF (F_{OFL}), the MSST for the fishing mortality effect, and the MSST for all other effects as the bases for evaluating the potential impacts of FMP 1 on Atka mackerel. Because the mean projected BSAI Atka mackerel Fs are below the overF, and the spawning stock is above its MSST in each of the projection years (2003-2007), the fishing mortality effect of FMP 1 is rated as insignificant. As noted above, the spawning stock biomass of BSAI Atka mackerel in each of the projection years (2003-2007) is above $B_{35\%}$ (B_{MSY} proxy), and therefore the BSAI Atka mackerel stock is determined to be above its MSST under FMP 1. For all other direct and indirect effects, it was determined that FMP 1 would not jeopardize the ability of the BSAI Atka mackerel stock to sustain itself at or above its MSST, and the effects were accordingly rated as insignificant.

Relative to the comparative baseline under FMP 1, the BSAI Atka mackerel stock is not overfished. Spawning biomass declines through 2005, after which biomass increases. Long-term projections (10- and 20-year projections) of spawning biomass show a very stable trend in biomass after 2007, with levels just above the 2007 level of 88,000 mt.

The F and the MSST for GOA Atka mackerel are unknown, and thus the effect of fishing mortality is unknown under FMP 1. As the MSST cannot be estimated for GOA Atka mackerel, which are in Tier 6, the significance of the spatial/temporal concentration and habitat suitability effects is also unknown under FMP 1. Although the MSST cannot be estimated for GOA Atka mackerel, due to the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 1 will not affect prey availability for BSAI or GOA Atka mackerel, and the potential impact on prey availability is considered to be insignificant.

Relative to the baseline, the GOA Atka mackerel stock under FMP 1 is likely to remain at a low abundance with continued low exploitation as a bycatch fishery only.

Status Determination from Modeling

Modeling projections for 2003-2007 suggest that under FMP 1, the future status of EBS and GOA atka mackerel stocks would be as follows for key indicators.

Stock Size Relative to MSST

Model projections of future catches of BSAI Atka mackerel are below the overfishing level in all years under FMP 1 (Table H.4-17 of Appendix H). Female spawning biomass in each of the projection years (2003-2007), is above $B_{35\%}$ (B_{MSY} proxy). These indicators suggest that the BSAI Atka mackerel stock is not overfished and is above its MSST under FMP 1.

GOA Atka mackerel are in Tier 6, and the MSST is unknown. Therefore, a status determination cannot be made for this stock.

Age and Size Composition

Under FMP 1, the mean age of BSAI Atka mackerel in 2007, as computed in model projections, is 2.74 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.82 years. Note that the mean ages and sizes actually observed in 2007 (as opposed to the model projections of mean age in 2007) will be driven largely by the strengths of incoming recruitments during the intervening years. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of its being a fished population with a greater than 30-year catch history. In the short-term, however, the impacts of the current fishing mortality levels on the stock would be overshadowed by the magnitude of incoming year-classes, which in turn are highly dependent on environmental conditions. The cumulative long-term impacts of the Fs could cause a shift in the age and size compositions.

Because the level of catch of GOA Atka mackerel is very low and projected to remain at the same low level under FMP 1, it is unlikely that the age and size compositions would change in the future under this FMP. Changes in the age and size compositions of GOA Atka mackerel are more likely driven by variations in recruitment than by the effects of fishing.

Sex Ratio

A 50:50 sex ratio is assumed for the BSAI Atka mackerel stock assessment and model projections. It is unknown what the true population sex ratio is, and what change, if any, would occur in the future under FMP 1. The current population sex ratio of GOA Atka mackerel is unknown. The true GOA population sex ratio and what changes, if any, would occur in the future under FMP 1 are unknown.

Cumulative Effects of FMP 1

External effects and the resultant cumulative effects associated with FMP 1 are shown in Tables 4.5-6 and 4.5-7. For further information regarding persistent past effects listed below in the text and in the tables, see the past/present effects analysis section of Sections 3.5.1.4 and 3.5.1.18.

BSAI Atka Mackerel

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Atka mackerel stock is insignificant under FMP 1 (see Section 4.5.1.4 direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the BSAI Atka mackerel stock. While large removals of Atka mackerel did occur in the past, there does not appear to be a lingering effect on the BSAI Atka mackerel populations (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as the only external event that could cause effects on the BSAI Atka mackerel population. Acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality.

- **Cumulative Effects.** A cumulative effect under FMP 1 is identified for mortality of BSAI Atka mackerel, but the effect is judged to be insignificant. Atka mackerel are fished at less than the OFL and are above the MSS. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Atka mackerel stock is expected to be insignificant under FMP 1 (see Section 4.5.1.4 direct/indirect effects discussion).

- **Persistent Past Effects.** While past large removals of Atka mackerel and other past effects on biomass have been identified (see Section 3.5.1.4), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality, and therefore would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the Atka mackerel biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As described under the internal effects section, the temporal/spatial concentration of the catch under FMP 1 does not appear to affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST.

- **Persistent Past Effects.** Since the Atka mackerel fishery was highly localized, past foreign, JV, and domestic fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. However, the effect of this change in distribution on genetic structure is unknown. Past commercial whaling and sealing removed large predators of Atka mackerel adding to the potential for reproductive success of the stock. Lingering past effects are also identified due to climate changes and regime shifts (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts

could have potential beneficial or potential adverse effects on Atka mackerel reproductive success. A shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** As described above under the direct/indirect effects section, the current levels and distribution of harvest do not appear to impact prey availability such that it affects the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST and the effect is judged insignificant.

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of Atka mackerel prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Atka mackerel prey species (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Climate changes and regime shifts could have potential beneficial or potential adverse effects on Atka mackerel reproductive success. A shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey species is not expected to decrease prey availability such that the Atka mackerel stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** As described in the direct/indirect effects section above, the level of habitat disturbance caused by the fishery under FMP 1 does not appear to affect the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST, and the effect is judged insignificant.

- **Persistent Past Effects.** Past effects are identified for BSAI Atka mackerel stocks include past foreign, JV, and domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.4). Intense bottom trawling for Atka mackerel in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Impacts on habitat from the climate changes and regime shifts could be either beneficial or adverse. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, that effect on the BSAI Atka mackerel stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Atka mackerel stock to sustain itself at or above MSST is jeopardized.

GOA Atka Mackerel

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Age structured models were not available for evaluation of impacts for the GOA; therefore model projections of future biomass levels were not produced.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Atka mackerel stock is unknown under FMP 1. The F and the MSST for GOA Atka mackerel are unknown; thus the effect of fishing mortality is unknown under FMP 1 (see Section 4.5.1.4, direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects of the past foreign, JV, and domestic, fisheries are likely for the GOA Atka mackerel stock. Large, concentrated removals of Atka mackerel occurred in the foreign, domestic, and JV fisheries and have had a lingering effect on the GOA Atka mackerel population, which has not yet recovered (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the population is jeopardized. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality.

- **Cumulative Effects.** A cumulative effect under FMP 1 is identified for mortality of GOA Atka mackerel, but the significance of the effect is unknown. GOA Atka mackerel are in Tier 6 and its MSST is unknown; therefore a status determination cannot be made.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Atka mackerel stock is unknown FMP 1. Current reliable estimates of total and spawning biomass are unknown for GOA Atka mackerel (see Section 4.5.1.4, direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects of the past foreign, JV, and domestic, fisheries are likely for the GOA Atka mackerel stock. Large, concentrated removals of Atka mackerel occurred in the

foreign, domestic, and JV fisheries and have had a lingering effect on the GOA Atka mackerel population which has not yet recovered (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the population is affected. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified; however, the significance of the effect is unknown.

<u>Spatial/Temporal Concentration of Catch</u>

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As the MSST cannot be estimated for GOA Atka mackerel which are in Tier 6, the significance of the spatial temporal concentration effects is also unknown under FMP 1 (see Section 4.5.1.4, direct/indirect effects discussion).

- **Persistent Past Effects.** Since the Atka mackerel fishery was highly localized, past foreign, JV, and domestic fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. However, the effect of this change in distribution on genetic structure is unknown. The past highly localized fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. Also, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Also, climate changes and regime shifts could impact spawning success since a shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the significance of the effect is unknown.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Although the MSST cannot be estimated for GOA Atka mackerel, due to the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 1 will not impact prey availability for BSAI Atka mackerel and the impact to the prey availability effect is determined to be insignificant (see Section 4.5.1.4, direct/indirect effects discussion).

- **Persistent Past Effects.** While lingering population level effects on the invertebrate prey of Atka mackerel from past foreign, state, and domestic fisheries, and the effects of EVOS on these species,

are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Atka mackerel prey species (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Atka mackerel prey species could be either beneficial or adverse depending on the direction of change. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is not identified for prey availability; however, the effects are unknown since the direction of external effects is unknown.

Change in Habitat Suitability

- **Direct/Indirect Effects.** As the MSST cannot be estimated for GOA Atka mackerel, which are in Tier 6, the significance of the habitat suitability effects is also unknown under FMP 1 (see Section 4.5.1.4, direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA Atka mackerel stocks include past foreign, JV, and domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.4). Intense bottom trawling for Atka mackerel in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat).

- **Reasonably Foreseeable Future External Effects.** Impacts on habitat from climate changes and regime shifts on the GOA Atka mackerel could be either favorable or unfavorable depending on the direction of change. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, their significance on the GOA Atka mackerel stock is unknown.

4.5.1.5 Yellowfin Sole and Shallow Water Flatfish

Numerous fishery management actions have been implemented that affect the yellowfin sole fisheries in the BSAI. These actions are described in more detail in Sections 3.5.1.5 and 3.5.1.19 of this Programmatic SEIS. Yellowfin sole is managed as its own stock under the BSAI groundfish FMP in the Tier 3 management category; thus MSSTs are defined for these species by the National Standard Guidelines.

Eight flatfish species inhabit shallow waters and are managed in the shallow water flatfish assemblage in the GOA. Yellowfin sole is included in this group, along with northern and southern rock sole, starry flounder, butter sole, English sole, Alaska plaice, and sand sole. Survey results from 2001 indicate that over half of the estimated biomass (54 percent) of this assemblage are northern and southern rock sole (Turnock *et al.* 2001). The shallow water group is managed as Tier 4 and Tier 5 species in the GOA.

As discussed in the following subsections, all potential direct and indirect effects of FMP 1 on this group are expected to be insignificant. External effects associated with the FMP 1 are shown in Tables 4.5-8 and 4.5-9 of Appendix A. For further information regarding persistent past effects listed below in the text and in Tables 4.5-8 and 4.5-9, see the past/present effects analysis discussion in Sections 3.5.1.5 and 3.5.1.19.

BSAI Yellowfin Sole – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI yellowfin sole. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The average annual fishing mortality imposed on the yellowfin sole stock in 2002 is 0.064. Model projections show that under FMP 1, this value would increase to 0.099 in 2006 and 2007 (Table H.4-4 of Appendix H). This value is well below the F_{MSY} proxy value of 0.138, the rate associated with the overfishing level. Because the capacity of the stock to produce MSY on a continuing basis would not be jeopardized under these conditions, the direct effect of FMP 1 on the mortality rate of BSAI yellowfin sole from fishing is expected to be insignificant.

Change in Biomass Level

Total Biomass

The total biomass of yellowfin sole at the start of 2002 is estimated to be 1,552,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-4 of Appendix H. Under FMP 1, model projections indicate that the total BSAI biomass is expected to decline by slightly more than 2 percent of the 2002 value to 1,520,000 mt by 2007, with a 2003-2007 average value of 1,531,000 mt. This projected decrease is considered to be insignificant, because total yellowfin sole biomass in the BSAI would stay within a range that would maintain the existing ability of the stock to sustain itself above the MSST.

Spawning Biomass

Spawning biomass of female yellowfin sole at the start of 2002 is estimated to be 450,700 mt. Model projections of future yellowfin sole spawning biomass estimates are shown in Table H.4-4 of Appendix H. Under FMP 1, model projections indicate that female spawning biomass is expected to decline by nearly 10 percent of the 2002 value to 409,000 mt by 2007, with a 2003-2007 average value of 433,500 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 336,900 mt throughout the five-year projection. Although the BSAI yellowfin sole spawning biomass is projected to decline, it would stay within a range that would maintain the existing ability of the stock to sustain itself above the MSST. Therefore, this potential effect under FMP 1 is considered to be insignificant.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual BSAI yellowfin sole harvest, relative to the 2002 baseline, would not be affected under FMP 1. Therefore, this potential impact is considered to be insignificant,

because it is not likely to cause changes in genetic structure or reproductive success that would jeopardize the ability of the stock to maintain itself at or above the MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. Because fishing practices under FMP 1 would be similar to the status quo, however, it is unlikely that future levels of habitat disturbance would lead to a detectable change in spawning or rearing success sufficient to jeopardize the ability of the stock to sustain itself at or above the MSST. Therefore, any direct or indirect effects of FMP 1 on BSAI yellowfin sole habitat suitability are expected to be insignificant.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on BSAI yellowfin sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. The current levels and distribution of harvest do not appear to affect prey availability in ways that impair the ability of the stock to maintain itself above its MSST, however, it is likely that potential effects of FMP 1 on prey availability for BSAI yellowfin sole would be insignificant.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Yellowfin Sole

Appendix A, Table 4.5-83 summarizes the expected effects of FMP 1 on BSAI yellowfin sole. The rating of conditionally significant (either beneficial or adverse) is not applicable in this analysis, because the model yields projections that can be classified only as significant (beneficial or adverse), insignificant, or unknown.

The ratings utilize F_{OFL} and the MSST as a basis for predicting beneficial or adverse impacts on fishing mortality and reproductive success, respectively, for each FMP. A thorough description of the rationale for the MSST can be found in the National Standard Guidelines, 50 CFR Part 600 (FR Vol. 63, No. 84, 24212-24237). Under FMP 1, the spawning stock biomass of BSAI yellowfin sole is expected to be above the MSST. The fishing mortality does not exceed F_{OFL}, and the female spawning stock is currently above the MSST; therefore, the expected changes under this FMP would not be substantial enough to change the genetic diversity or reproductive success of the spawning stocks. For this reason, the potential indirect and direct effect sof this FMP on BSAI yellowfin sole are considered insignificant.

Relative to the 2002 comparative baseline, the yellowfin sole stock is not projected to be continually overfished under this FMP. The 20-year projection indicates that the female spawning stock would decline to B_{ABC} levels until 2010 and increase thereafter through the end of the projection in 2023.

Status Determination from Modeling

Model projections for 2003-2007 indicate that under FMP 1, the future status of the BSAI yellowfin sole stock would be as follows for key indicators.

Stock Size Relative to MSST

Model projections of future catches of BSAI yellowfin sole are below the OFLs in all years under FMP 1. The yellowfin sole stock is above the MSST level in 2002 (Table H.4-4 of Appendix H).

Age and Size Composition

Under FMP 1, the mean age of the BSAI yellowfin sole stock in 2008, as computed in model projections (Table H.4-4 of Appendix H), is 6.2 years. This compares with a mean age in the equilibrium unfished BSAI stock of 8.0 years. Note that the mean age and size actually observed in 2008 (as opposed to the model projections) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of yellowfin sole in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

External effects and the resultant cumulative effects associated with FMP 1 are shown in Table 4.5-8.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI yellowfin sole is rated as insignificant under FMP 1 (see the direct/indirect effects discussion above).

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI yellowfin sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause yellowfin sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of yellowfin sole.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI yellowfin sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As described in the direct/indirect effects section, it is not expected that FMP 1 will result in any significant adverse impact to these stocks.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI yellowfin sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause yellowfin sole mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse contributions on the yellowfin sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.5 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI yellowfin sole, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock and the spawning biomass is above the B_{MSY} value. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

<u>Spatial/Temporal Concentration of Catch</u>

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock (see the direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI yellowfin sole catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of yellowfin sole due to climate changes and regime shifts are potentially beneficial or adverse. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI yellowfin sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the yellowfin sole catch; however, this effect is ranked as insignificant. The spatial/temporal distribution of yellowfin sole catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI yellowfin sole is ranked as insignificant (see the direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the BSAI yellowfin sole stock and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted. See Sections 3.5.1.5 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI yellowfin sole stock are potentially beneficial or adverse. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** Cumulative effects are identified for change in prey availability; however, these effects are considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI yellowfin sole is ranked as insignificant. Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. However, it is determined that FMP 1 would have insignificant effects on yellowfin sole habitat suitability (see the direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects identified for BSAI yellowfin sole include climate changes and regime shifts. In the past, when the Aleutian Low was strong and water temperatures warm, catch tended to be dominated by flatfish species, implying increased recruitment. In contrast, when the Aleutian Low was weak and water temperatures cooler, catch tended to be dominated by shrimp. Persistent past effects of the foreign, JV, and domestic fisheries gear impacts are described in Sections 3.5.1.5 and 3.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI yellowfin sole stock are potentially beneficial or adverse. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for BSAI yellowfin sole habitat suitability; however, these effects are considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the yellowfin sole stock to sustain itself at or above the MSST is jeopardized.

GOA Shallow Water Flatfish – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on the GOA shallow water flatfish complex. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Fishing Mortality

The catch of GOA shallow water flatfish in 2002 was estimated to be 6,800 mt. Model projections of future catch are shown in Table H.4-27 of Appendix H. Under FMP 1, model projections indicate that the catch is expected to decrease from the 2002 value to 5,400 mt in 2003-2006 and to 5,100 mt in 2007. The 2003-2007 average catch is projected to be 5,300 mt under FMP 1. Although information necessary to determine MSY is lacking for shallow water flatfish, the projected decrease in catch under this FMP suggests that effects of fishing mortality are likely to be insignificant, because they would not be expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

No reliable estimates for total or spawning biomass are available for GOA shallow water flatfish. Therefore, potential effects of FMP 1 relating to changes in biomass are unknown for this group.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual GOA shallow water flatfish harvest under FMP 1 would be similar to baseline conditions. However, evidence is insufficient to conclude whether spatial and temporal patterns of harvest concentration would lead to a detectable change in genetic diversity or reproductive success, and MSSTs have not been established for the species in this group. Therefore, any potential effects of the spatial/temporal concentration of the catch on shallow water flatfish under this FMP are unknown.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP, and MSSTs have not been defined for the shallow water flatfish species. Therefore, potential effects of FMP 1 on habitat suitability for this group are unknown.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on shallow water flatfish would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP nor have MSSTs been defined for the shallow water flatfish species. Therefore, potential effects of FMP 1 on prey availability for this group are unknown.

Summary of Direct and Indirect Effects of FMP 1 on GOA Shallow Water Flatfish

The direct and indirect effects of FMP 1 on GOA shallow water flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. Available information is insufficient to estimate female spawning biomass of these stocks over the five-year projection and what level of fishing mortality would correspond to the modeled catch estimated under this FMP. Because catch volumes are predicted to decline moderately over the five-year period, the effect of FMP 1 on fishing mortality is likely to be insignificant. All other direct and indirect effects of FMP 1 on the shallow water flatfish complex are unknown, because available information on the stocks is insufficient to determine MSSTs.

Status Determination from Modeling

Stock Size Relative to MSST

The available information for flatfish species in the shallow water complex requires that they be classified into either the Tier 4 or Tier 5 management category. As a result, no MSSTs are defined for these species in the National Standard Guidelines. Therefore, it is not possible to determine the status of their stocks relative to MSST.

Age and Size Composition

Under FMP 1, the mean age of the GOA shallow water flatfish stock in 2008, as computed in model projections, is 4.7 years. This compares with a mean age in the equilibrium unfished GOA stock of 5.9 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of shallow water flatfish in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-9 summarizes the cumulative effects analysis for GOA shallow water flatfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA shallow water flatfish is rated as insignificant under FMP 1 (see the direct/indirect effects discussion).

- **Persistent Past Effects.** Past, JV, and domestic fisheries have been identified as having lingering past adverse effects on th GOA shallow water flatfish complex. See Section 3.5.1.19 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse contributions of marine pollution, since acute and/or chronic pollution events could cause shallow water flatfish species mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shallow water flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor since shallow water flatfish species by catch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA shallow water flatfish, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** Since the total and spawning biomass estimates for GOA shallow water species is unavailable, the effects of FMP 1 on change in biomass are unknown (see the direct/indirect effects discussion).

- **Persistent Past Effects.** The past, JV, and domestic fisheries are identified as having past lingering adverse effects on the biomass levels of GOA shallow water flatfish. See Section 3.5.1.19 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse contributions of marine pollution; acute and/or chronic pollution events could cause shallow water flatfish species mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse contributions on the shallow water flatfish species biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.19 and 3.10. The State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of shallow water flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for change in biomass of GOA shallow water flatfish, but is rated as unknown. Fishing mortality at projected levels is well below the OFL for this stock. It is unknown if the combined effects of internal and external removals are likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal distribution of the annual GOA shallow water flatfish harvest will not be affected under FMP 1, relative to the 2002 baseline year. However, little is known

about the spatial/temporal characteristics of GOA shallow water flatfish, therefore the effects of FMP 1 are rated as unknown (see the direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects have not been identified for the change in genetic structure or the change in reproductive success of GOA shallow water flatfish (see Section 3.5.1.19).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of shallow water flatfish species due to climate changes and regime shifts are potentially beneficial or adverse. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock complex. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA shallow water flatfish. The State of Alaska scallop fishery has been identified as a non-contributing factor to the change in genetic structure and reproductive success since bycatch of shallow water flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** Cumulative effects are possible for change in genetic structure and reproductive success of GOA shallow water flatfish, but are rated as unknown. It is unknown if the combined effects of internal removals and removals due to reasonably foreseeable future external events are likely to jeopardize the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the GOA shallow water flatfish is determined to be unknown (see the direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the GOA shallow water flatfish stock complex and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted. See Sections 3.5.1.19 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA shallow water flatfish stock complex are potentially beneficial or adverse. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The State of Alaska scallop fishery is identified as a non-contributing factor since by catch of shallow water flatfish prey species is not expected to occur in this fishery.

- **Cumulative Effects.** Cumulative effects for change in prey availability are unknown. The predation-mediated impacts of FMP 1 on shallow water flatfish are governed by a complex web of indirect interactions which are currently difficult to quantify.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the GOA shallow water flatfish complex is considered to be unknown. Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify (see the direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects identified for GOA shallow water flatfish include climate changes and regime shifts. In the past, when the Aleutian Low was strong and water temperatures warm, catch tended to be dominated by flatfish species, implying increased recruitment. In contrast, when the Aleutian Low was weak and water temperatures cooler, catch tended to be dominated by shrimp. Persistent past effects of the foreign, JV, and domestic fisheries gear impacts are described in Sections 3.5.1.19 and 3.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA shallow water flatfish stock complex are potentially beneficial or adverse. A strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery is also identified as a potential adverse contributor to GOA shallow water flatfish habitat suitability. See Section 3.6.4 for information of the impacts of fishery gear on EFH.

- **Cumulative Effects.** Cumulative effects are identified for GOA shallow water flatfish habitat suitability; however, these effects are unknown. It is unknown if the combination of internal and external habitat disturbances will to lead to a detectable change in spawning or rearing success such that the ability of the GOA shallow water flatfish stock to maintain current population levels is jeopardized.

4.5.1.6 Rock Sole

Numerous fishery management actions have been implemented that affect the rock sole fisheries in the BSAI. These actions are described in more detail in Section 3.5.1.6 of this Programmatic SEIS. Rock sole is managed as its own stock under the BSAI groundfish FMP as a Tier 3 management category; therefore, an MSST is defined for this species.

Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI rock sole. As discussed below, all potential direct and indirect effects of FMP 1 on this group are expected to be insignificant. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The average annual fishing mortality imposed on the rock sole stock in 2002 is 0.055. Model projections suggest this value will increase to 0.137 in 2007 (Table H.4-7 of Appendix H). These values are well below the F_{MSY} proxy value of 0.21, the rate associated with the OFL. Therefore, the projected Fs for BSAI rock sole under FMP 1 are considered to be insignificant, because they would not jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

The total biomass of rock sole at the start of 2002 is estimated to be 970,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-7 of Appendix H. Under FMP 1, the model projections indicate that the total BSAI biomass is expected to decline 30 percent of the 2002 value to 680,000 mt by 2007, with a 2003-2007 average value of 765,000 mt. This projected decrease is considered to be insignificant, because total rock sole biomass in the BSAI would stay within a range that would maintain the existing ability of the stock to sustain itself above the MSST.

Spawning Biomass

Spawning biomass of female rock sole at the start of 2002 is estimated to be 331,000 mt. Model projections of future rock sole spawning biomass estimates are shown in Table H.4-7 of Appendix H. Under FMP 1, model projections indicate that female spawning biomass is expected to decline to 53 percent of the 2002 value to 175,900 mt by 2007, with a 2003-2007 average value of 238,100 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 136,700 mt throughout the five-year projection. Although spawning biomass for BSAI rock sole is projected to decline, it would stay within a range that would maintain the existing ability of the stock to sustain itself above the MSST. Therefore, this potential effect under FMP 1 is considered to be insignificant.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual BSAI rock sole harvest, relative to the 2002 baseline year, would not be affected under FMP 1. The temporal/spatial concentration of the catch under baseline conditions does not appear to affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST. Under FMP 1, therefore, the spatial and temporal pattern of catch concentration would have an insignificant effect on BSAI rock sole relative to the baseline.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 on BSAI rock sole would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. The level of habitat disturbance caused by the fishery under baseline conditions does not appear to

affect the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST. Therefore, impacts on habitat suitability for BSAI rock sole are expected to be insignificant under FMP 1.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on rock sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. The current levels and distribution of harvest do not appear to affect prey availability in ways that impair the ability of the rock sole stock to maintain itself above its MSST. Therefore, it is likely that potential effects of FMP 1 on prey availability for BSAI rock sole would be insignificant.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Rock Sole

Appendix A, Table 4.5-83 summarizes the expected direct and indirect effects of FMP 1 on BSAI rock sole. The rating of conditionally significant (either beneficial or adverse) is not applicable in this analysis, because the model projections yielded results that could be evaluated only as significant (beneficial or adverse), insignificant, or unknown.

The ratings utilize F_{OFL} and MSST as the bases for identifying potentially beneficial or adverse impacts on fishing mortality and reproductive success under each FMP. A thorough description of the rationale for the MSST can be found in the National Standard Guidelines, 50 CFR Part 600 (FR Vol. 63, No. 84, 24212-24237). Under FMP 1, the spawning stock biomass of BSAI rock sole is expected to be above the MSST. Since the F would not exceed F_{OFL} and the stock is expected to remain above the MSST, the expected changes under this FMP would not be substantial enough that the genetic diversity or reproductive success of the spawning stocks would be likely to change under the new management regime. Therefore, the potential direct and indirect effects on BSAI rock sole under this FMP are considered insignificant.

Relative to the 2002 comparative baseline, the rock sole stock is projected to continue not to be overfished under this FMP. The 20-year projection indicates that the female spawning stock is expected to decline to a level just less than B_{MSY} in 2010, then increase to above B_{ABC} levels by 2015, and continue to increase through the end of the projection in 2023.

Status Determination from Modeling

Model projections for 2003-2007 suggest that under FMP 1, the future status of the BSAI rock sole stock would be as follows for key indicators.

Stock Size Relative to MSST

Model projections of future catches of BSAI rock sole are below the OFLs in all years under FMP 1, and the female spawning stock is above the MSST. The rock sole stock is projected to be above the MSST level in 2002.

Age and Size Composition

Under FMP 1, the mean age of the BSAI rock sole stock in 2008, as computed in model projections (Table H.4-7 of Appendix H), is 4.7 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.9 years. Note that the mean age and size actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of rock sole in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-10 summarizes the cumulative effects analysis for BSAI rock sole.

Mortality

- **Direct/Indirect Effects.** As stated above in the direct/indirect effects section, the effect of fishing mortality on the BSAI rock sole is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause rock sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of rock sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI rock sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on BSAI rock sole biomass is rated as insignificant.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse contribution of marine pollution; acute and/or chronic

pollution events could cause rock sole mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the rock sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.6 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI rock sole, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the BSAI rock sole. Climate changes and regime shifts have been identified as having a persistent past effect on the reproductive success of BSAI rock sole. Climate changes and regime shifts and corresponding water temperature variation could affect prey availability and habitat suitability, which in combination could affect the reproductive success of the rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of rock sole due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI rock sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the rock sole catch, and is ranked as insignificant. The spatial/temporal distribution of rock sole catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the change in prey availability for the BSAI rock sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts. Climate changes and regime shifts and corresponding water temperature variation do affect the availability of some forage species (i.e. capelin); however, studies on benthic invertebrates have not been conducted. See Section 3.5.1.6 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI rock sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the change in habitat suitability for the BSAI rock sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI rock sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI rock sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI rock sole habitat suitability; however, this effect is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the rock sole stock to sustain itself at or above the MSST is jeopardized.

4.5.1.7 Flathead Sole

Numerous fishery management actions have been implemented that affect the flathead sole fisheries in the BSAI and GOA. These actions are described in more detail in Sections 3.5.1.7 and 3.5.1.20 of this Programmatic SEIS. Flathead sole is managed as its own stock under the BSAI groundfish FMP within the Tier 3 management category; therefore, an MSST is defined for this species by the National Standard Guidelines. Beginning in 2002, flathead sole were managed independently of the other flatfish species in the GOA. Until recently, GOA flathead sole were evaluated under the Tier 4 management category; beginning in 2004, flathead sole will be managed under Tier 3. GOA flathead sole were modeled under the Tier 4 category for this analysis.

BSAI Flathead Sole – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the analyses of direct and indirect impacts of FMP 1 on BSAI flathead sole. As discussed below, all of these potential effects are expected to be insignificant. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The projected fishing mortality imposed on the BSAI flathead sole stock in 2003 is 0.047. Model projections suggest that under FMP 1, this fishing mortality would increase to 0.086 in 2008, with an average fishing mortality of 0.063 from 2003-2008 (Table H.4-8 of Appendix H). These values are below the $F_{35\%}$ level of 0.355 and the $F_{40\%}$ level of 0.286, which are taken as proxies for F_{ABC} and F_{OFL}, respectively. The proportion of spawner biomass per recruit conserved under these mortality rates is 80 percent in 2003, decreasing to 70 percent in 2008; the average implied spawner biomass per recruit (SPR) rate of fishing from 2003-2008 is 76 percent. These projections indicate that the expected effects of FMP 1 on BSAI flathead sole mortality are likely to be insignificant, because they would not jeopardize the capacity of the stocks to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

Total biomass (ages 3 through 21+) of BSAI flathead sole at the start of 2003 is estimated to be 513,000 mt. Model projections of future BSAI total flathead sole biomass are shown in Table H.4-8 of Appendix H. Under FMP 1, model projections indicate that BSAI flathead sole biomass is expected to decrease to a value of 490,000 mt in 2006, then increase to 498,000 mt in 2008. The 2003-2008 projected average total biomass is 497,000 mt. These projections indicate that the total flathead sole biomass in the BSAI would stay within a range that would maintain the existing ability of the stock to sustain itself above the MSST. For this reason, the impact of FMP 1 on BSAI flathead sole total biomass is expected to be insignificant.

Spawning Biomass

Spawning biomass of BSAI flathead sole at the start of 2003 is estimated to be 231,200 mt. Model projections of future total BSAI flathead sole spawning biomass are shown in Table H.4-8 of Appendix H. Under FMP 1, model projections indicate that BSAI flathead sole spawning biomass would increase to a value of 164,600 mt in 2008, with a 2003-2008 average value of 196,000 mt. Under FMP 1, therefore, impacts on BSAI flathead sole spawning biomass are expected to be insignificant, because the existing ability of the stock to sustain itself above the MSST would be maintained.

Spatial/Temporal Concentration of Catch

The harvest of flathead sole occurs largely along the western edge of the EBS shelf; little harvest occurs in the Aleutian Islands. Although some directed fishing for flathead sole exists, a considerable amount of harvest occurs as bycatch in other target fisheries. Under FMP 1, an average of 12,900 mt is projected to be harvested annually from 2003-2008, almost entirely from the EBS. The EBS Pacific cod and yellowfin sole fisheries account for 3,240 mt (25 percent) and 2,530 mt (19 percent) of the average annual harvest, whereas the directed flathead sole fishery accounts for 1,910 mt (15 percent). Recent observer data indicate that the harvest of flathead sole occurs year-round, and is determined largely from the seasonal allocations of the Pacific halibut prohibited species bycatch limits for flatfish trawl fisheries (Spencer *et al.* 2001). Because these patterns would be maintained under FMP 1, the temporal/spatial concentration of the catch would not be likely to affect the sustainability of the stock either through changes in the genetic structure of the

population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST. Therefore, this potential impact is considered to be insignificant.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under this FMP 1. Therefore, the effects of FMP 1 on BSAI flathead sole habitat suitability are expected to be insignificant, because the present ability of the stock to maintain itself above the MSST would not be impaired.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under this FMP. Since the current levels and distribution of harvest have not been shown to affect prey availability in ways that impair the ability of the stock to maintain itself above its MSST, potential future effects of FMP 1 on prey availability for BSAI flathead sole are likely to be insignificant.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Flathead Sole

Because BSAI flathead sole are fished at less than the OFL and are above the MSST, the direct and indirect effects of FMP 1 on this stock are considered insignificant. Fishing rates are well within accepted scientific standards based on studies of population dynamics and estimates of natural variations in recruitment. Therefore, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity.

Relative to the 2002 comparative baseline, the flathead sole stock is projected to continue not tot be overfished under this FMP. The 20- year projection indicates that the female spawning stock would decrease until 2009, then begin to increase steadily through the end of the projection. The female spawning stock is estimated to remain above B_{ABC} throughout the projection.

Status Determination from Modeling

Stock Size Relative to MSST

Under FMP 1, the ABC is set at a lower level than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI flathead sole are below the ABC and OFL levels in all years. The BSAI flathead sole are above their MSST in the year 2002.

Age and Size Composition

Under FMP 1, the mean age of the BSAI flathead sole stock in 2008, as computed in model projections, is 4.53 years. This compares with a mean age in the equilibrium unfished stock of 5.39 years.

Sex Ratio

The sex ratio of BSAI flathead sole is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-11 summarizes the cumulative effects analysis for BSAI flathead sole.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI flathead sole is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of flathead sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI flathead sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fishing on the flathead sole biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the flathead sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.7 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI flathead sole, and is rated as insignificant. Fishing mortality at projected levels is well below the

OFL for this stock and the spawning biomass is above the B_{MSY} value. The combined effect of internal removals and removals due to reasonable foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI flathead sole catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of flathead sole due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI flathead sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the flathead sole catch, and is ranked as insignificant. The spatial/temporal distribution of flathead sole catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI flathead sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects are not identified for the change in prey availability of the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI flathead sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI flathead sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI flathead sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.7.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI flathead sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI flathead sole habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the flathead sole stock to sustain itself at or above the MSST is jeopardized.

GOA Flathead Sole – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the analyses of direct and indirect impacts of FMP 1 on GOA flathead sole. The effect of fishing mortality on this stock is expected to be insignificant, whereas the significance of other potential direct and indirect effects is unknown. Significance ratings are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The catch of GOA flathead sole in 2002 was estimated to be 2,000 mt. Model projections of future catch are shown in Table H.4-28 of Appendix H. Under FMP 1, model projections indicate that the catch would decrease from the 2002 value to 1,700 mt in 2003 and then further decline to 1,500 mt in 2007 (75 percent of 2002 catch). The 2003-2007 average catch is 1,600 mt. Therefore, the projected Fs for GOA flathead sole under FMP 1 are considered to be insignificant, because they would not jeopardize the capacity of the stocks to produce MSY on a continuing basis.

Change in Biomass Level

Estimates of total and spawning biomass are not available for this species. Therefore, the potential effects of FMP 1 on biomass levels, and any resulting impact on the stock's ability to maintain itself above the MSST, are unknown.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual GOA flathead sole harvest would not be affected under FMP 1, relative to the 2002 baseline year. However, the effects of the temporal/spatial concentration of the

catch on this stock under baseline conditions are unknown. Therefore, the potential effects of FMP 1 to affect the stock's genetic structure or reproductive success must also be considered unknown.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 on GOA flathead sole would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next five years under this FMP. Because habitat-mediated impacts under baseline conditions are unknown, however, the potential habitat-mediated effects of FMP 1 on the stock's ability to maintain itself above the MSST must also be considered unknown.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on GOA flathead sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Because data on prey availability under baseline conditions are not available, however, potential predation-mediated impacts of FMP 1 on the ability of the GOA flathead sole stock to sustain itself at or above the MSST are unknown.

Summary of Direct and Indirect Effects of FMP 1 on GOA Flathead Sole

Because the GOA flathead sole catch is projected to decrease moderately during the 2003-2007 period, the effect of FMP 1 on fishing mortality is expected to be insignificant. All other direct and indirect effects of FMP 1 on GOA flathead sole are unknown, because they cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks would be over the five-year projection and what level of fishing mortality would correspond to the modeled catch estimated under this FMP.

Status Determination from Modeling

Stock Size Relative to MSST

The available information for flathead sole requires that this species be classified into the Tier 4 management category. As a result, no MSSTs are defined for flathead sole, and it is not possible to determine the status of the stock size relative to MSST.

Age and Size Composition

Age and size composition estimates are not available for this species.

Sex Ratio

The sex ratio of flathead sole in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-12 summarizes the cumulative effects analysis for GOA flathead sole.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA flathead sole is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have been identified for fishing mortality in the GOA flathead sole stock and include past, JV, and domestic fisheries. Removals by these fisheries have had a lingering adverse effect on GOA flathead sole. For more information, see Section 3.5.1.20.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of flathead sole. The State of Alaska scallop fishery has also been identified as a non-contributing factor since GOA flathead sole bycatch is not expected in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA flathead sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonable foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the change in biomass level is rated as unknown since MSST is unable to be determined at this time.

- **Persistent Past Effects.** Past effects have been identified for fishing mortality in the GOA flathead sole stock and include past, JV, and domestic fisheries. Large removals of flathead sole by these fisheries is determined to have had a lingering effect on the GOA flathead sole stock (see Section 3.5.1.20).

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the flathead sole biomass level. For more information on climate changes and regime shifts, see Sections 3.5.1.20 and 3.10. The State of Alaska scallop fishery is identified as a non-contributing factor for change in biomass level since flathead sole bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA flathead sole, but is unknown. The MSST is not able to be determined and the total and spawning

biomass estimates are currently unavailable. It is unknown whether the combined effect of internal and external removals are likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown since the MSST is unable to be determined.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the GOA flathead sole stock. However, climate changes and regime shifts have been identified as having a beneficial or adverse effect on GOA flathead sole reproductive success. See Section 3.5.1.20 for more information on the effects of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of flathead sole due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA flathead sole. The State of Alaska scallop fishery has been identified as a non-contributing factor to change in genetic structure and change in reproductive success since GOA flathead sole bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the flathead sole catch; however, this effect is unknown. It is unknown whether the combined effect of internal and external removals are likely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain current population levels is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the GOA flathead sole is unknown.

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the GOA flathead sole stock and include climate changes and regime shifts. For more information on the effects of climate changes and regime shifts on the GOA flathead sole stock, see Section 3.5.1.20.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA flathead sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The State of Alaska scallop fishery is identified as a potential adverse contributor to GOA flathead sole prey availability. The State of Alaska scallop fishery gear could impact flathead sole benthic prey availability and/or quality.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown. It is unknown whether the combination of internal and external removals of prey is expected to jeopardize the ability of the stock to sustain itself at current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the GOA flathead sole is unknown. Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify.

- **Persistent Past Effects.** Past effects identified for GOA flathead sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.20.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA flathead sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery is identified as a potential adverse contributor to GOA flathead sole habitat suitability. For information on the effects of fishery gear on EFH, see Section 3.6.4.

- **Cumulative Effects.** A cumulative effect is identified for GOA flathead sole habitat suitability; however, this effect is unknown. It is unknown whether the combination of internal and external habitat disturbances is expected to lead to a detectable change in spawning or rearing success such that the ability of the flathead sole stock to sustain itself at current population levels.

4.5.1.8 Arrowtooth Flounder

Numerous fishery management actions have been implemented that affect the arrowtooth flounder fisheries in the BSAI and GOA. These actions are described in more detail in Sections 3.5.1.8 and 3.5.1.21 of this Programmatic SEIS. Arrowtooth flounder is managed as its own stock under the BSAI and GOA groundfish FMPs as part of the Tier 3 management category. Therefore, MSSTs are defined for these stocks.

BSAI Arrowtooth Flounder – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI arrowtooth flounder. All of these potential effects are expected to be insignificant. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The average annual fishing mortality imposed on the BSAI arrowtooth flounder stock in 2002 is 0.015. Model projections show this value will increase to 0.26 in 2007. These values are well below the F_{MSY} proxy value of 0.38, the rate associated with the overfishing level. This impact is expected to be insignificant, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

The total biomass of BSAI arrowtooth flounder at the start of 2002 is estimated to be 811,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-6 of Appendix H. Under FMP 1, model projections indicate that the total BSAI biomass is expected to decline 26 percent of the 2002 value to 597,000 mt by 2007, with a 2003-2007 average value of 675,000 mt. Because total biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spawning Biomass

Spawning biomass of female BSAI arrowtooth flounder at the start of 2002 is estimated to be 475,900 mt. Model projections of future arrowtooth flounder spawning biomass estimates are shown in Table H.4-6 of Appendix H. Under FMP 1, model projections indicate that female spawning biomass is expected to decline to 30 percent of the 2002 value to 329,500 mt by 2007, with a 2003-2007 average value of 387,900 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 182,900 mt throughout the five-year projection. Because spawning biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual BSAI arrowtooth flounder harvest, relative to the 2002 baseline, would not be affected under FMP 1. This impact is expected to be insignificant, because the concentration of harvest would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. Therefore, the effects of FMP 1 on habitat suitability are expected to be insignificant, because future levels of habitat disturbance would not lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on BSAI arrowtooth flounder would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Therefore, this impact is expected to be insignificant, because there is no evidence that future FMP 1 harvest levels or distribution of harvest would lead to a change in prey availability such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Arrowtooth Flounder

Under FMP 1, the spawning stock biomass of BSAI arrowtooth flounder is expected to be above the MSST. Since the F does not exceed F_{OFL} and the female spawning stocks are expected to remain above the MSST, the expected changes under this FMP are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under this FMP are considered insignificant.

Relative to the 2002 comparative baseline, the BSAI arrowtooth flounder stocks are projected to continue to not be overfished under this FMP. The 20-year projection indicates that the female spawning stock in both areas is expected to remain above B_{ABC} levels through the end of the projection in 2023.

Status Determination from Modeling

Modeling projections for 2003-2007 indicate that under FMP 1, the future status of BSAI arrowtooth flounder would be as follows for key indicators.

Stock Size Relative to MSST

Model projections of future catches of BSAI arrowtooth flounder are below the overfishing levels in all years under FMP 1. The arrowtooth flounder female spawning biomass is above the MSST level in 2002.

Age and Size Composition

Under FMP 1, the mean age of the BSAI arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-6 of Appendix H), is 4.8 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.4 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

Fishery-independent resource assessment surveys in the BSAI have found that populations of arrowtooth flounder are comprised of a higher percentage of females than males. It is believed that this is a function of a higher natural mortality rate for males than females. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-13 summarizes the cumulative effects analysis for BSAI arrowtooth flounder.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI arrowtooth flounder is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause arrowtooth flounder mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of arrowtooth flounder. The IPHC longline fishery is identified as a potential adverse contributor to BSAI arrowtooth flounder mortality since arrowtooth flounder are caught as bycatch in this fishery. Finally, the State of Alaska herring fishery is identified as a non-contributing factor to BSAI arrowtooth flounder mortality since bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI arrowtooth flounder, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on the BSAI arrowtooth flounder biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass level in the BSAI arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass level are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause arrowtooth flounder mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the arrowtooth flounder biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.8 and 3.10. The IPHC longline fishery has been identified as a potential adverse contributor to BSAI arrowtooth flounder biomass level since bycatch is expected to occur in this fishery. Finally, the State of Alaska herring fishery is identified as a non-contributing factor since arrowtooth flounder bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI arrowtooth flounder, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI arrowtooth flounder. Climate changes and regime shifts are identified as having had potential adverse or beneficial effects on the reproductive success of BSAI arrowtooth flounder (see Section 3.5.1.8 for more information).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of arrowtooth flounder due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI arrowtooth flounder. The IPHC longline fishery is identified as a non-contributing factor to the genetic structure and reproductive success of BSAI arrowtooth flounder since the removals are not expected to be significant. The State of Alaska herring fishery is also identified as a non-contributing factor to the genetic structure and reproductive success of BSAI arrowtooth flounder since bycatch is not expected in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the arrowtooth flounder catch, and is ranked as insignificant. The spatial/temporal distribution of arrowtooth flounder catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified include the past foreign, JV, domestic fisheries, State of Alaska groundfish fisheries, State of Alaska herring fisheries, and climate changes and regime shifts. See Section 3.5.1.8 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI arrowtooth flounder stock are potentially beneficial or adverse. Some forage species (i.e. capelin and herring), shrimp and pollock respond to variations in water temperatures which vary with the climate. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The IPHC longline fishery is identified as a non-contributing factor to prey availability since the bycatch of prey species

is not expected in this fishery. The State of Alaska herring fishery is identified as a potential adverse contributor to prey availability by reducing the availability of herring.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI arrowtooth flounder include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.8.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI arrowtooth flounder stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fishery and the State of Alaska herring fishery are both identified as non-contributing factors to BSAI arrowtooth flounder habitat suitability. The impacts from the fishery gear is expected to be minimal.

- **Cumulative Effects.** A cumulative effect is identified for BSAI arrowtooth flounder habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the arrowtooth flounder stock to sustain itself at or above the MSST is jeopardized.

GOA Arrowtooth Flounder – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on GOA arrowtooth flounder. All of these potential effects are expected to be insignificant. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The average annual fishing mortality imposed on the GOA arrowtooth flounder stock in 2002 is 0.017. Model projections show this value will decrease to 0.009 in 2007. These values are well below the F_{MSY} proxy value of 0.165, the rate associated with the overfishing level. This impact is expected to be insignificant, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

The total biomass of GOA arrowtooth flounder at the start of 2002 is estimated to be 1,816,000 mt. Model projections of future total GOA biomass estimates are shown in Table H.4-29 of Appendix H. Under FMP 1, model projections indicate that the total GOA biomass is expected to increase 15 percent of the 2002 value to 2,086,000 mt by 2007, with a 2003-2007 average value of 1,982,000 mt. Because total biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spawning Biomass

Spawning biomass of female GOA arrowtooth flounder at the start of 2002 is estimated to be 1,113,800 mt. Model projections of future GOA arrowtooth flounder spawning biomass estimates are shown in Table H.4-29 of Appendix H. Under FMP 1, model projections indicate that female spawning biomass is expected to increase 4 percent of the 2002 value to 1,115,700 mt by 2007, with a 2003-2007 average value of 1,142,300 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 432,700 mt throughout the five-year projection. Because spawning biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual GOA arrowtooth flounder harvest, relative to the 2002 baseline, would not be affected under FMP 1. Therefore, this impact is expected to be insignificant, because the concentration of harvest would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. Therefore, the effects of FMP 1 on habitat suitability are expected to be insignificant, because future levels of habitat disturbance would not lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on GOA arrowtooth flounder would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Therefore, this impact is expected to be insignificant, because there is no evidence that future FMP 1 harvest levels or distribution of harvest would lead to a

change in prey availability such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on GOA Arrowtooth Flounder

Under FMP 1, the spawning stock biomass of GOA arrowtooth flounder is expected to be above the MSST. Since the F does not exceed F_{OFL} and the female spawning stocks are expected to remain above the MSST, the expected changes under this FMP are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Therefore, the indirect and direct effects under this FMP are considered insignificant.

Relative to the 2002 comparative baseline, the GOA arrowtooth flounder stocks are projected to continue not to be overfished under this FMP. The 20-year projection indicates that the female spawning stock in both areas is expected to remain above B_{ABC} levels through the end of the projection in 2023.

Status Determination from Modeling

Model projections of future catches of GOA arrowtooth flounder are below the overfishing levels in all years under FMP 1. The arrowtooth flounder female spawning biomass is above the MSST level in 2002.

Age and Size Composition

Under FMP 1, the mean age of the GOA arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-29 of Appendix H), is 5.0 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.1 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

Fishery-independent resource assessment surveys in the GOA have found that populations of arrowtooth flounder are comprised of a higher percentage of females than males. It is believed that this is a function of a higher natural mortality rate for males than for females. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-14 summarizes the cumulative effects analysis for GOA arrowtooth flounder.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA arrowtooth flounder is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the GOA arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA arrowtooth flounder, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on the biomass level is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for change in biomass in the GOA arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are the same as those described for BSAI arowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA arrowtooth flounder, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects identified for the change in genetic structure and reproductive success of GOA arrowtooth flounder are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success and genetic structure of arrowtooth flounder are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the arrowtooth flounder catch and is ranked as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the GOA arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified include climate changes and regime shifts. See Section 3.5.1.21 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on prey availability are the same as those discussed for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the GOA arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for GOA arrowtooth flounder include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.21.

- **Reasonably Foreseeable Future External Effects.** Future external effects on habitat suitability are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for GOA arrowtooth flounder habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the arrowtooth flounder stock to sustain itself at or above the MSST is jeopardized.

4.5.1.9 Greenland Turbot and Deepwater Flatfish

The numerous fishery management actions that affect the Greenland turbot fisheries in the BSAI are described in more detail in Section 3.5.1.9 of this Programmatic SEIS. Greenland turbot is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category; thus MSSTs are defined for these species by the National Standard Guidelines. The reference F and ABC for the GOA deepwater flatfish management group are determined by the amount of population information available. ABCs for Dover sole were calculated using Tier 5. Greenland turbot and deepsea sole are in Tier 6 because no reliable biomass estimates exists. Section 3.5.1.22 discusses the past/present effects analysis for GOA deepwater flatfish.

BSAI Greenland Turbot – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI Greenland turbot. All of these impacts are expected to be insignificant. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The average annual fishing mortality imposed on the Greenland turbot stock in 2002 is 0.052. Model projections indicate that under this FMP the F will reach a maximum in 2004 of 0.19 and decrease thereafter to 0.162 by 2007. These values are well below the F_{MSY} proxy value of 0.48, the rate associated with the OFL. This impact is expected to be insignificant, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

The total biomass of Greenland turbot at the start of 2002 is estimated to be 106,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-5 of Appendix H. Under FMP 1, model projections indicate that the total BSAI biomass is expected to decline 19 percent of the 2002 value to 86,000 mt by 2007, with a 2003-2007 average value of 92,000 mt. Because total biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spawning Biomass

Spawning biomass of female Greenland turbot at the start of 2002 is estimated to be 67,800 mt. Model projections of future Greenland turbot spawning biomass estimates are shown in Table H.4-5 of Appendix H. Under FMP 1, model projections indicate that female spawning biomass is expected to decline to 31 percent of the 2002 value to 46,800 mt by 2007, with a 2003-2007 average value of 54,100 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 47,600 mt in the first four years of the projection, and would be below the B_{MSY} proxy rate in 2007. Because spawning biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual BSAI Greenland turbot harvest, relative to the 2002 baseline, would not be affected under FMP 1. This impact is expected to be insignificant, because the concentration of harvest would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. Therefore, the effects of FMP 1 on habitat suitability are expected to be insignificant, because future levels of habitat disturbance would not lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on Greenland turbot would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Therefore, this impact is expected to be insignificant, because there is no evidence that future FMP 1 harvest levels or distribution of harvest would lead to a change in prey availability such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Greenland Turbot

Under FMP 1, the spawning stock biomass of BSAI Greenland turbot is expected to be above the MSST. Since the F does not exceed F_{OFL} and the stock is expected to remain above the MSST, the expected changes under this FMP are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under this FMP are considered insignificant.

Relative to the 2002 comparative baseline, the Greenland turbot stock is projected to continue not to be overfished under this FMP. The 20-year projection indicates that the female spawning stock is expected to decline until 2007 to below B_{MSY} levels and will increase thereafter through the end of the projection to be above B_{ABC} in 2023.

Status Determination from Modeling

Stock Size Relative to MSST

Model projections of future catches of BSAI Greenland turbot are below the OFLs in all years under FMP 1. The Greenland turbot stock is above the MSST level in 2002.

Age and Size Composition

Under FMP 1, the mean age of the BSAI Greenland turbot stock in 2008, as computed in model projections (Table H.4-5 of Appendix H), is 4.6 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.9 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Greenland turbot in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects Analysis of FMP 1

Table 4.5-15 summarizes the cumulative effects analysis for BSAI Greenland Turbot.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Greenland turbot is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause Greenland turbot mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of Greenland turbot.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Greenland turbot and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on the change in biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause Greenland turbot mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the Greenland turbot biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts see Sections 3.5.1.9 and 3.10.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI Greenland turbot and is rated as insignificant. Fishing mortality at projected levels is well below the

OFL for this stock and the female spawning biomass is above the B_{MSY} value from 2003-2006. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the spatial/temporal concentration of BSAI Greenland turbot catch. Climate changes and regime shifts are suspected of having an effect on the reproductive success of the Greenland turbot stock. See Section 3.5.1.9 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of Greenland turbot due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI Greenland turbot.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the Greenland turbot catch and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the BSAI Greenland turbot stock. Past foreign, JV, and domestic fisheries have been identified as having influenced the availability of Greenland turbot prey, mainly pollock, which is their main prey item in the BSAI. Climate changes and regime shifts have also been identified as influencing Greenland turbot prey availability. See Section 3.5.1.9 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI Greenland turbot stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI Greenland turbot include climate changes and regime shifts. The foreign, JV, and domestic fisheries have also influenced the habitat suitability of Greenland turbot, largely through the impacts of fishing gear on benthic habitats. See Section 3.5.1.9 for more information on the persistent past effects on Greenland turbot.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI Greenland turbot stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI Greenland turbot habitat suitability and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Greenland turbot stock to sustain itself at or above the MSST is jeopardized.

GOA Deepwater Flatfish – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on the GOA deepwater flatfish complex. The potential effect of FMP 1 on this complex through fishing mortality is expected to be insignificant. The significance of all other potential direct and indirect effects on this group is unknown. Significance ratings are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The catch of GOA deepwater flatfish in 2002 was estimated to be 600 mt. Model projections of future catch are shown in Table H.4-25 of Appendix H. Under FMP 1, model projections indicate that the catch is expected to increase two and a half times the 2002 value to 1,600 mt by 2007, with a 2003-2007 average value of 1,600 mt. This impact is expected to be insignificant, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Reliable estimates of total and spawning biomass do not exist for these species. Consequently, the potential impact of FMP 1 on GOA deepwater flatfish biomass levels is unknown, because MSSTs have not been determined for the species in this group.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual GOA deepwater flatfish harvest would not be affected under FMP 1, relative to the 2002 baseline. However, the effects of the temporal/spatial concentration of the catch on this stock under baseline conditions are unknown. Therefore, the potential effects of FMP 1 to affect genetic structure or reproductive success within the GOA deepwater flatfish populations must also be considered unknown.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 on the GOA deepwater flatfish complex would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat- mediated impacts would undergo significant qualitative change during the next five years under this FMP. Therefore, evidence is insufficient to conclude whether future levels of habitat disturbance would lead to a change in spawning or rearing success that would affect the ability of the stock to sustain itself at or above the MSST under FMP 1.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on deepwater flatfish would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Therefore, evidence is insufficient to conclude whether future harvest levels and distribution of harvest under this FMP would lead to a change in prey availability that would affect the stock's ability to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on GOA Deepwater Flatfish

The direct and indirect effects of FMP 1 on GOA deepwater flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks would be over the five-year projection and what level of fishing mortality would correspond to the modeled catch estimated under this FMP.

Status Determination from Modeling

Stock Size Relative to MSST

The available information for flatfish species in the deepwater complex requires that they are classified into either the Tier 5 or Tier 6 management category. As a result, no MSSTs are defined for these species in the National Standard Guidelines. Therefore, it is not possible to determine the status of their stock size relative to MSST.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

The sex ratio of deepwater flatfish in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-16 summarizes the cumulative effects analysis for GOA deepwater flatfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA deepwater flatfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the GOA deepwater flatfish stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause deepwater flatfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of deepwater flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of deepwater flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA deepwater flatfish and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Total and spawning biomass estimates are unavailable for the deepwater flatfish species, therefore, the effects of FMP 1 on the change in biomass level are unknown.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the GOA deepwater flatfish stock complex.

- **Reasonably Foreseeable Future External Effects.** Future external effects. on the change in biomass are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause deepwater flatfish mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the deepwater flatfish species biomass level. For more information on climate changes and regime shifts, see Sections 3.5.1.22 and 3.10. The State of Alaska scallop fishery has been identified as a non-contributing factor for change in biomass level since deepwater flatfish species bycatch is not expected to occur.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA deepwater flatfish, but is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown for the stock since the MSST is unable to be determined.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts which are suspected of having an effect on the reproductive success of the deepwater flatfish stock complex. See Section 3.5.1.22 for more information on the effects of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of GOA deepwater flatfish due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA deepwater flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor to change in genetic structure and reproductive success since bycatch of GOA deepwater flatfish species is not expected to occur.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the GOA deepwater flatfish catch; however, this effect unknown. It is unknown whether the combined effect of internal and external removals is likely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain current population levels is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the GOA deepwater flatfish complex is unknown.

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the GOA deepwater flatfish stock complex and include climate changes and regime shifts. See Section 3.5.1.22 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA deepwater flatfish stock complex are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The State of Alaska scallop fishery has been identified as a potential adverse contributor to benthic prey availability. See Section 3.6.4 for information of the impacts of fishery gear on EFH.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown. It is unknown whether the combination of internal and external removals of prey is expected to jeopardize the ability of the stock to maintain current populations.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the GOA deepwater flatfish complex is unknown.

- **Persistent Past Effects.** Past effects identified for GOA deepwater flatfish include climate changes and regime shifts. The foreign, JV, and domestic fisheries have also influenced the habitat suitability of deepwater flatfish, largely through the impacts of fishing gear on benthic habitats. See Section 3.5.1.22 for more information on the persistent past effects on deepwater flatfish.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA deepwater flatfish stock complex are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery has been identified as a potential adverse contributor to habitat suitability. See Section 3.6.4 for more information on the impacts of fishery gear on EFH.

- **Cumulative Effects.** A cumulative effect is identified for GOA deepwater flatfish habitat suitability; however, this effect is unknown. It is unknown whether the combination of internal and external habitat disturbances is expected to lead to a detectable change in spawning or rearing success such that the ability of the deepwater flatfish stock complex to maintain current population levels is jeopardized.

4.5.1.10 Alaska Plaice and Other Flatfish and Rex Sole

The numerous fishery management actions that have affected the Alaska plaice, other flatfish, and rex sole fisheries in the BSAI and GOA are described in more detail in Sections 3.5.1.10 and 3.5.1.23 of this Programmatic SEIS.

Alaska plaice is evaluated under Tier 3a of Amendment 56 (Spencer *et al.* 2002b). Estimates of MSST are available for this stock. Although there are fifteen species considered as part of the "other flatfish" complex, only seven species comprise the majority of the catch. The other flatfish assemblage is managed under Tier 5, although it has been managed under Tier 4 and 3a in the past (Spencer *et al.* 2002a). Estimates of MSST are not available for this stock. The reference F and ABC for rex sole are determined by the amount of population information available. ABCs are calculated using $F_{ABC} = 0.75$ M and $F_{OFL} = M$ (Tier 5), because maturity information is not available.

BSAI Alaska Plaice – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI Alaska plaice. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The projected fishing mortality imposed on the BSAI Alaska plaice stock in 2003 is 0.017. Model projections show this fishing mortality will remain at this level through 2005,then increase to 0.021 in 2006 and 2007, and lower to 0.019 in 2008 (Table H.4.9 of Appendix H). These values are below the $F_{35\%}$ level of 0.344 and the $F_{40\%}$ level of 0.279, which are taken as proxies for F_{ABC} and F_{OFL}, respectively. The proportion of SPR conserved under these mortality rates is 92 percent in 2003, decreases to 90 percent in 2006, and increases to 91 percent in 2008. The average implied SPR rate of fishing from 2003-2008 is 91 percent. The impact of fishing mortality on BSAI Alaska plaice is expected to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

Total biomass (ages 1 through 25+) of BSAI Alaska plaice at the start of 2003 is estimated to be 1,083,000 mt. Model projections of future total BSAI Alaska plaice biomass are shown in Table H.4.9 of Appendix H. Under FMP 1, model projections indicate that BSAI biomass is expected to increase to a value of 1,121,000 mt in 2008, with a 2003-2008 average value of 1,104,000 mt. Because total biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spawning Biomass

Spawning biomass of BSAI Alaska plaice at the start of 2003 is estimated to be 275,900 mt. Model projections of future total BSAI Alaska plaice biomass are shown in Table H.4.9 of Appendix H. Under FMP 1, model projections indicate that BSAI Alaska plaice biomass is expected to increase to a value of 283,300 mt in 2008, with a 2003-2008 average value of 278,800 mt. Because spawning biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spatial/Temporal Concentration of Catch

Alaska plaice is a relatively low-valued flatfish species that is taken as bycatch on the EBS shelf; little harvest occurs in the Aleutian Islands. Under FMP 1, an average of 10,500 mt is projected to be harvest annually from 2003-2008, coming nearly entirely from the EBS. The EBS yellowfin sole and rock sole fisheries account for most of the catch, contributing 7,450 mt (71 percent) and 1,440 mt (14 percent) of the average annual harvest. Recent observer data indicate that the harvest of Alaska plaice occurs year-round, and are determined largely from the seasonal allocations of the Pacific halibut prohibited species bycatch limits for flatfish trawl fisheries (Spencer *et al.* 2001). The impact of the spatial/temporal pattern of the harvest under FMP 1 is expected to be insignificant because the harvest concentration would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the BSAI Alaska plaice stock to sustain itself at or above its MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under this FMP 1. There is no evidence that future levels of habitat disturbance would lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the BSAI Alaska plaice stock to sustain itself at or above the MSST. Therefore, this impact is expected to be insignificant under FMP 1.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 1. There is no evidence that future distribution of harvest would lead to a change in prey availability such that it would jeopardize the ability of the BSAI Alaska plaice stock to sustain itself at or above the MSST. Therefore, this impact is expected to be insignificant under FMP 1.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Alaska Plaice

Because BSAI Alaska plaice are fished at less than the OFL and are above the MSST, the direct and indirect effects under FMP 1 are considered insignificant. Fishing rates are well within accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity.

Relative to the 2002 comparative baseline, the Alaska plaice stock is projected to continue not to be overfished under this FMP. The 20-year projection indicates that the female spawning stock is expected to remain at a high and stable level well above B_{ABC}.

Status Determination from Modeling

Stock Size Relative to MSST

Under FMP 1, the ABC is set at a lower level than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI Alaska plaice are below the ABC and OFL levels in all years. The BSAI Alaska plaice are above their respective MSST in the year 2002.

Age and Size Composition

Under FMP 1, the mean age of the BSAI Alaska plaice stock in 2008, as computed in model projections, is 4.40 years. This compares with a mean age in the equilibrium unfished stock of 4.51 years.

Sex Ratio

The sex ratio of BSAI Alaska plaice is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-17 summarizes the cumulative effects analysis for BSAI Alaska plaice.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Alaska plaice is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for BSAI Alaska plaice mortality.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause other flatfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of Alaska plaice. For more information on climate changes and regime shifts, see Sections 3.5.1.10 and 3.10.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Alaska plaice and is rated as insignificant. Fs for projected years are well below the other flatfish OFL. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is rated as insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass of BSAI Alaska plaice.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause other flatfish mortality. Climate changes and regime shifts have also been identified as having an indirect potentially beneficial or adverse effect on the Alaska plaice biomass level. When the Aleutian Low is strong and water temperatures warm, flatfish recruitment is favored, whereas when the Aleutian Low is weak and the temperatures cooler, recruitment tends to be weak. For more information on climate changes and regime shifts, see Sections 3.5.1.10 and 3.10.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI Alaska plaice and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable future external events is not expected to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is identified as insignificant.

- **Persistent Past Effects.** Past effects are not identified for genetic structure of the population. However, climate changes and regime shifts are identified as having persistent past effects on the reproductive success of the BSAI Alaska plaice stock. See Sections 3.5.1.10 and 3.10 for more information of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the genetic structure of other flatfish include the potential adverse effects of marine pollution; acute and/or chronic pollution events could alter the genetic structure of the population by causing localized mortality. Climate changes and regime shifts have been identified as non-contributing factors to the change in genetic structure of the Alaska plaice stocks. These events are not expected to cause localized depletions that would significantly alter the genetic sub-population structure of the Alaska plaice stock. Change in reproductive success of Alaska plaice due to climate changes and regime shifts is identified as potentially beneficial or adverse. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could also the reproductive success of BSAI Alaska plaice.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the Alaska plaice catch and is rated as insignificant. The combined effect of internal removals and external removals are not expected to jeopardize the capacity of the stock to sustain itself above the MSST.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI Alaska plaice is insignificant.

- **Persistent Past Effects.** Climate changes are identified as having effected prey availability of the BSAI Alaska plaice stock. The actual effect of climate changes and regime shifts on Alaska plaice prey availability is unknown, but could have had a potentially beneficial or adverse effect. See Sections 3.5.1.10 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI Alaska plaice stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution

events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable future external events are not expected to jeopardize the capacity of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI Alaska plaice is rated as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI Alaska plaice include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potentially beneficial or adverse effect. Habitat disturbances caused by the past foreign, JV, and domestic fisheries have also been identified as having persistent past effects on the BSAI Alaska plaice stock See Sections 3.5.1.10 and 3.10 for more information regarding the past fisheries and climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI Alaska plaice stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI Alaska plaice habitat suitability and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable future external events is not expected to jeopardize the capacity of the stock to sustain itself above the MSST.

BSAI Other Flatfish – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on the BSAI other flatfish complex. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The catch of BSAI other flatfish in 2002 was estimated to be 2,600 mt. Model projections of future catch are shown in Table H.4.10 of Appendix H. Under FMP 1, model projections indicate that the catch is expected to decrease from the 2002 value to 2,200 mt in 2003 and then increase each year to 2,500 mt in 2007 (5 percent decrease from 2002). The 2003-2007 average catch is 2,300 mt. The impact of fishing mortality on BSAI other flatfish is expected to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total and spawning biomass estimates are not available for these species. Therefore, the potential impact of FMP 1 on biomass level is unknown, because the MSST cannot be determined.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual BSAI other flatfish harvest would not be affected under FMP 1, relative to the 2002 baseline year. Evidence is insufficient to conclude whether the harvest concentration under FMP 1 would lead to a detectable change in genetic diversity or reproductive success that would affect the stock's ability to sustain itself at or above the MSST. Therefore, the impact of the spatial/temporal pattern of the catch on BSAI other flatfish under FMP 1 is unknown.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. Because evidence is not available to determine whether, under FMP 1, future levels of habitat disturbance would lead to a change in spawning or rearing success that would affect the ability of the BSAI other flatfish stocks to sustain themselves at or above their MSSTs, this potential impact is unknown.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on other flatfish would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Consequently, evidence is not available to determine whether future harvest levels and distribution of harvest under this FMP would lead to a change in prey availability that would affect the ability of the BSAI other flatfish stocks to sustain themselves at or above their MSSTs. Therefore, this potential impact is unknown.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Other Flatfish

The direct and indirect effects of FMP 1 on BSAI other flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks is over the five-year projection and what level of fishing mortality corresponds to the modeled catch estimated under this FMP.

Status Determination from Modeling

Stock Size Relative to MSST

The available information for flatfish species in the other flatfish complex requires that they are classified into either the Tier 4 or Tier 5 management category. As a result, no MSSTs are defined for these species

in the National Standard Guidelines. Therefore, it is not possible to determine the status of their stock sizes relative to their MSSTs.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

The sex ratios of the species in the other flatfish category in the BSAI are assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-18 summarizes the cumulative effects analysis for BSAI other flatfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI other flatfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects have not been identified for BSAI other flatfish mortality.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI other flatfish and is rated as insignificant. Fs for projected years are well below the other flatfish OFL. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is rated as unknown since the MSST for this stock is not possible to be determined.

- **Persistent Past Effects.** Past effects have not been identified for the BSAI other flatfish change in biomass level effect indicator.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI other flatfish, but this effect is unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for the spatial/temporal concentration of catch are the same as those described for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects identified for the spatial/temporal concentration of catch are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the other flatfish catch, but this effect is unknown since the MSST is not possible to be determined. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI other flatfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for the change in prey availability are the same as those described for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects identified for the change in prey availability are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability. However, this effect is unknown since it is not possible to determine the MSST. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI other flatfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for habitat suitability of BSAI other flatfish are the same as those described for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects identified for habitat suitability are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for BSAI other flatfish habitat suitability; however, this effect is unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

GOA Rex Sole – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on GOA rex sole. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The catch of GOA rex sole in 2002 was estimated to be 3,000 mt. Model projections of future catch are shown in Table H.4.26 of Appendix H. Under FMP 1, model projections indicate that the catch is expected to increase from the 2002 value to 3,300 mt in 2003and then decrease thereafter to 2,500 mt in 2007. The 2003-2007 average catch is 3,000 mt. The impact of fishing mortality on GOA rex sole is expected to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total and spawning biomass estimates are not available for this species, and the MSST cannot be determined. Therefore, the potential effect of FMP 1 on GOA rex sole biomass levels is unknown.

Spatial/Temporal Concentration of Catch

The spatial/temporal characteristics of the annual GOA rex sole harvest would not be affected under FMP 1, relative to the 2002 baseline year. Evidence is insufficient to conclude whether the harvest concentration under FMP 1 would lead to a detectable change in genetic diversity or reproductive success that would affect the stock's ability to sustain itself at or above the MSST. Therefore, the impact of the spatial/temporal pattern of the catch on GOA rex sole under FMP 1 is unknown.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. The potential impact of FMP 1 is unknown because evidence is not available to determine whether future levels of habitat disturbance would lead to a change in spawning or rearing success that would affect the ability of the GOA rex sole stock to sustain itself at or above the MSST.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 on rex sole would be governed by a complex web of indirect interactions which are currently difficult to quantify. Information is insufficient

to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Therefore, it is unknown whether future harvest levels and distribution of harvest would lead to a change in prey availability that would affect the GOA rex sole stock's ability to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on GOA Rex Sole

The direct and indirect effects of FMP 1 on GOA rex sole cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. Potential changes in the F would be too small to affect MSY and are therefore considered insignificant. It is unknown what the estimate of female spawning biomass of this stock would be over the five-year projection and what level of fishing mortality would correspond to the modeled catch estimated under this FMP.

Status Determination from Modeling

Stock Size Relative to MSST

The available information for rex sole requires that they are classified in the Tier 5 management category. As a result, no MSSTs are defined for these species in the National Standard Guidelines. Therefore, it is not possible to determine the status of their stock size relative to MSST.

Age and Size Composition

Age and size composition estimates are not available for this species.

Sex Ratio

The sex ratio of rex sole in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-19 summarizes the cumulative effects analysis for GOA rex sole.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA rex sole is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Large removals of rex sole by the past foreign, JV, and domestic fisheries have been identified as having had an adverse persistent past effect on GOA rex sole stocks. See Section 3.5.1.23 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause rex sole mortality. Climate changes and regime shifts are considered

non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of rex sole. The State of Alaska scallop fishery has also been identified as a non-contributing factor since it is not expected to contribute to direct mortality of rex sole.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA rex sole and is rated as insignificant. Fs for projected years are well below the rex sole OFL. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is rated as unknown since the MSST for this stock is not possible to be determined.

- **Persistent Past Effects.** Large removals of rex sole by past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA rex sole stocks. See Section 3.5.1.23 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause rex sole mortality. Climate changes and regime shifts have also been identified as having an indirect potentially beneficial or adverse effect on the rex sole biomass level. The State of Alaska Scallop Fishery is identified as a non-contributing factor since it is not expected to contribute to direct mortality of rex sole. For more information on climate changes and regime shifts, see Sections 3.5.1.23 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA rex sole, but is the effect is unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects are not identified for genetic structure of the population; however, climate changes and regime shifts are identified as having persistent past effects on the reproductive success of the GOA rex sole stock. See Sections 3.5.1.23 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the genetic structure of rex sole include the potential adverse effects of marine pollution; an acute and/or chronic

pollution event could alter the genetic structure of the population by causing localized mortality. The State of Alaska scallop fishery and climate changes and regime shifts have both been identified as non-contributing factors to the change in genetic structure of rex sole stocks. These events are not expected to cause localized depletions that would alter the genetic sub-population structure of rex sole stock. Change in reproductive success of rex sole due to climate changes and regime shifts is identified as having a potentially beneficial or adverse effect. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could also the reproductive success of GOA rex sole. Again, the State of Alaska scallop fishery has been identified as a non-contributing factor since the scallop fishery is not expected to contribute to rex sole removals.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the rex sole catch; however, these effects are unknown since the MSST is not possible to be determined. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the GOA rex sole is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Climate change and regime shifts have been identified as having effected the change in prey availability of the GOA rex sole stock. The actual effect of climate changes and regime shifts on rex sole prey availability is unknown, but could have had a potentially beneficial or adverse effect. See Sections 3.5.1.23 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA rex sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The State of Alaska scallop fishery has been identified as having a potential adverse effect on rex sole prey availability since the habitat disturbances caused by dredging could influence the benthic prey availability.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the GOA rex sole is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for GOA rex sole include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown,

but could have a potentially beneficial or adverse effect. Habitat disturbances caused by the past foreign, JV, and domestic fisheries have also been identified as having persistent past effects on the GOA rex sole stock. See Sections 3.5.1.23 and 3.10 for more information regarding the past fisheries and climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA rex sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery is identified as having potential adverse effects on rex sole habitat suitability that may cause changes in the spawning or rearing success of the stock.

- **Cumulative Effects.** A cumulative effect is identified for GOA rex sole habitat suitability; however, this effect is unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

4.5.1.11 Pacific Ocean Perch

Pacific ocean perch (*Sebastes alutus*) are managed as a single stock in the EBS, Aleutian Islands, and GOA, and separate assessments are made for each region. Within the GOA, ABC limits are apportioned within four management areas in an effort to reduce the risk of localized depletion. Trawl fishing is not permitted in the southeast/east Yakutat area and the ABC (approximately 12 percent of the total GOA ABC) normally allocated to that area is not likely to be caught. Pacific ocean perch are managed under Tier 3 in both the BSAI and GOA.

BSAI Pacific Ocean Perch – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on BSAI and GOA Pacific ocean perch. All of these potential effects are expected to be insignificant. The significance ratings are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The projected fishing mortality imposed on the BSAI Pacific ocean perch stock in 2003 is 0.033. Model projections show this fishing mortality will decrease to 0.027 in 2005 and then increase to 0.033 in 2008 (Table H.4-12 of Appendix H). These values are below the $F_{35\%}$ level of 0.057 and the $F_{40\%}$ level of 0.048, which are taken as proxies for F_{ABC} and F_{OFL}, respectively. The implied SPR fishing rates under FMP 1 is 51 percent in 2003, increasing to 56 percent in 2005, and decreasing to 51 percent in 2008. The average implied SPR rate of fishing from 2003-2008 is 51 percent. The impact of fishing mortality on BSAI Pacific ocean perch is expected to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

Total biomass (ages 3 through 21+) of BSAI Pacific ocean perch at the start of 2003 is estimated to be 374,000 mt. Model projections of future total BSAI Pacific ocean perch biomass are shown in Table H.4-12 of Appendix H. Under FMP 1, model projections indicate that BSAI Pacific ocean perch biomass is expected to increase to a value of 396,000 mt in 2008, with a 2003-2008 average value of 385,000 mt. Because total biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spawning Biomass

Spawning biomass of BSAI Pacific ocean perch at the start of 2003 is estimated to be 135,500 mt. Model projections of future total BSAI Pacific ocean perch biomass are shown in Table H.4-12 of Appendix H. Under FMP 1, model projections indicate that BSAI Pacific ocean perch biomass is expected to decrease to a value of 135,300 mt in 2004, then increase to a value of 138,800 mt in 2008, with a 2003-2008 average value of 136,800 mt. Because spawning biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spatial/Temporal Concentration of Catch

In recent years, the Pacific ocean perch directed fishery in the Aleutian Islands typically occurs in the month of July. Fishery observer data from 2000-2002 indicates that approximately 80 percent of the Pacific ocean perch in the BSAI are harvested during this month; there is no directed fishing for Pacific ocean perch in the EBS management area. Projected harvest under FMP 1 indicates that an average of 10,600 mt is harvested in the BSAI area, with 49 percent from the eastern Aleutians, 23 percent from the western Aleutians, 22 percent from the central Aleutians, and 6 percent from the EBS. This impact is expected to be insignificant, because the concentration of harvest under FMP 1 would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under this FMP 1.Therefore, the effects of FMP 1 on habitat suitability are expected to be insignificant, because future levels of habitat disturbance would not lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 1. Therefore,

this impact is expected to be insignificant, because there is no evidence that future FMP 1 harvest levels or distribution of harvest would lead to a change in prey availability such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Pacific Ocean Perch

Because BSAI Pacific ocean perch are fished at less than the OFL and are above the minimum stock size threshold, the direct and indirect effects under FMP 1 are considered insignificant. Fishing rates are well within accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity.

Status Determination from Modeling

Stock Size Relative to MSST

Under FMP 1, the ABC is set at a lower level than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI Pacific ocean perch are below the ABC and OFL levels in all years, and projected spawning stock biomass is above B_{MSY} ($B_{35\%}$) level of 120,200 mt; thus, BSAI Pacific ocean perch are determined to be above the MSST level under FMP 1 (Table H.4-12 of Appendix H).

Age and Size Composition

Under FMP 1, the mean age of the BSAI Pacific ocean perch stock in 2008, as computed in model projections, is 10.38 years. This compares with a mean age in the equilibrium unfished stock of 14.01 years.

Sex Ratio

The sex ratio of BSAI Pacific ocean perch is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-20 summarizes the cumulative effects analysis for BSAI Pacific ocean perch.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Pacific ocean perch stock is insignificant under FMP 1.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries are identified as having had adverse effects on the BSAI Pacific ocean perch stock. Large removals of Pacific ocean perch occurred in the past and there appears to be a lingering effect on the BSAI populations (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute to BSAI Pacific ocean perch mortality since bycatch in this fishery is not expected. Marine pollution is identified as making a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific ocean perch mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Pacific ocean perch and is rated as insignificant. Pacific ocean perch are fished at less than the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Pacific ocean perch stock is expected to be insignificant under FMP 1.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries are identified as having had adverse effects on the BSAI Pacific ocean perch stock. Large removals of Pacific ocean perch occurred in the past and there appears to be a lingering effect on the BSAI populations (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute significantly to BSAI Pacific ocean perch change in biomass since bycatch is not expected in this fishery. Therefore, the IPHC longline fishery is also not expected to cause significant changes in biomass levels. Marine pollution is identified as making a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as making beneficial or adverse contributions to Pacific ocean perch change in biomass levels as a function of reproductive success.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the Pacific ocean perch biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the BSAI Pacific ocean perch population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure. However, there are lingering past effects due to climate changes and regime shifts (see Section 3.5.1.11) for change in reproductive success.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute to changes in genetic structure or reproductive success of BSAI Pacific ocean perch since bycatch of BSAI Pacific ocean perch is not expected to occur. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as potentially beneficial or adverse contributor to reproductive success since changes in climate can affect prey availability and/or habitat suitability which in turn can affect recruitment. Generally, changes in climate changes that lead to increased advection of the Alaska current are believed to increase euphausiid production, a major prey item of BSAI Pacific ocean perch. Climate changes and regime shifts are not considered to contribute to changes in genetic structure.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** It is determined that FMP 1 would have insignificant effects on Pacific ocean perch prey availability.

- **Persistent Past Effects.** Past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific ocean perch prey species (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Pacific ocean perch prey species are identified as potentially beneficial or adverse contributors. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific ocean perch stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** It is determined that FMP 1 would have insignificant effects on Pacific ocean perch habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for BSAI Pacific ocean perch stocks include past foreign, JV, and domestic fisheries, IPHC longline fisheries, climate changes and regime shifts (see Section 3.5.1.11). Intense bottom trawling on Pacific ocean perch habitat in the past fisheries likely disrupted spawning and/or rearing habitats in areas of the BSAI. It is possible that some of these areas have not recovered from the intense efforts. The IPHC longline fisheries are also identified as having adverse effects on Pacific ocean perch habitat, although these fishing gear

impacts are considered to be less significant than those associated with trawl gear (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat). Climate changes and regime shifts have had both beneficial and adverse effects on Pacific ocean perch habitat.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is identified as making adverse contributions to Pacific ocean perch habitat through fishing gear impacts. As stated above, these impacts are expected to be of lesser magnitude than those effects associated with trawl gear. Impacts on habitat from climate changes and regime shifts on the BSAI Pacific ocean perch stock are identified as potentially beneficial or adverse contributors, although the magnitude and direction of the change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the BSAI Pacific ocean perch stock to sustain itself at or above MSST is jeopardized.

GOA Pacific Ocean Perch – Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on GOA Pacific ocean perch. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1. Section 3.5.1.24 discusses the past/present effects analysis for GOA Pacific ocean perch in more detail.

Total and Spawning Biomass and Fishing Mortality

ABC is used as a proxy for TAC in model projections. The FMP 1 model projections for GOA Pacific ocean perch catch are unrealistically low relative to projected ABC. For example, from 1997 to 2001 catch of Pacific ocean perch in the western, central, and eastern GOA has averaged 76 percent of the ABC (Heifetz *et al.* 2002). Average projected catch for the years 2003-2008 under FMP 1 is only 57 percent of projected ABC. Consequently, average catch under FMP 1 would likely be higher (average of 76 percent of projected ABC) for the years 2003-2008. Spawning biomass, fishing mortality, vulnerable biomass, and implied SPR rates would also change relative to an average catch of 76 percent of projected ABC for the years 2003-2008. However, average fishing mortality during the years 2003-2008 is still expected to be less than F_{OFL} (0.060) (Table H.4-36 of Appendix H). Because total and spawning biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1. The impact of fishing mortality on GOA Pacific ocean perch is also expected to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Spatial/Temporal Concentration of Catch

Under FMP 1, trawl fishing is not permitted in the southeast/east Yakutat area and the ABC (approximately 12 percent of the total GOA ABC) normally allocated to that area is not likely to be caught. Under FMP 1,

GOA Pacific ocean perch are taken in the central (80 percent of GOA Pacific ocean perch captured), western (13 percent), and eastern (7 percent) GOA, primarily in directed Pacific ocean perch bottom trawl fisheries (74 percent of GOA Pacific ocean perch captured), directed Pacific ocean perch pelagic trawl fisheries (11 percent), and as bycatch in directed bottom trawl fisheries for other rockfish species (11 percent).

Under FMP 1, the ABC for Pacific ocean perch is determined for the entire GOA, and then geographically apportioned among management areas. This apportionment spreads fishery effort over the GOA and reduces the risk of localized depletion. In the GOA, Pacific ocean perch are taken largely in directed fisheries and the fishery tends to concentrate in slope areas away from the proposed closures for Steller sea lion prey species under FMP 1.

Under FMP 1, the Pacific ocean perch trawl fishery would be managed as under the current GOA FMP which has an open season that occurs in July and generally lasts a few weeks. The open fishery system compresses the fishery effort into a short time period and creates difficulty for the management of the fishery by increasing the risk of possible overfishing if the fishery is not closed before catch exceeds ABC.

For the reasons discussed above, the impact of the spatial/temporal concentration of catch on GOA Pacific ocean perch is expected to be insignificant under FMP 1, because the concentration of harvest would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Habitat Suitability

Under FMP 1, bottom trawling or other fishing gear in contact with the ocean floor of the GOA continental shelf and upper slope could adversely affect the habitat of juvenile Pacific ocean perch. Juvenile Pacific ocean perch tend to live inshore in shallower depths than adults, and may also be associated with epifauna that provides structural relief on the bottom such as corals or sponges. If so, damage to this epifauna by bottom trawls may reduce survival of juvenile fish.

At the same time, FMP 1 would reduce impacts to GOA Pacific ocean perch habitat because it would close the eastern GOA to trawling. This would create a *de facto* no-take zone or refugium for Pacific ocean perch in this area, as trawls are generally the only effective gear for capturing this species. Biomass estimates from trawl surveys indicate that the trawl closure area in the eastern GOA contains 12 percent of the GOA biomass of Pacific ocean perch. Consequently, this refugium may be large enough to provide enhanced protection to the rockfish resource. Use of refugia as a conservation measure could be particularly effective for rockfish species, as most are generally believed to be sedentary in nature and not undergo extensive migrations. The closed areas may allow increased survival of larger and older fish that produce significantly more eggs and larvae to replenish the GOA population. The trawl closure would also prevent damage to the benthic environment in the eastern GOA, because bottom trawls would no longer be used. Although little is known about the habitat preferences of Pacific ocean perch, an undamaged benthic habitat likely provides a benefit to the adults as well as juveniles of this species.

On balance, FMP 1 would create conditions for both beneficial and adverse impacts on GOA Pacific ocean perch habitat. It is unlikely, however, that future levels of habitat disturbance under FMP 1 would lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Prey Availability

The major prey of Pacific ocean perch is euphausiids, and Pacific ocean perch may in turn be preyed upon by large piscivorous fish. There is no indication that existing trophic interactions would undergo significant qualitative change under FMP 1. Therefore, this impact is expected to be insignificant, because there is no evidence that future FMP 1 harvest levels or distribution of harvest would lead to a change in prey availability such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on GOA Pacific Ocean Perch

The analysis of potential direct and indirect effects on GOA Pacific ocean perch is based on stock sustainability as indexed by projection model estimates of fishing mortality relative to the overfishing limit (F_{OFL}), and by projection model estimates of female spawning stock biomass relative to the MSST.

Under FMP 1, average fishing mortality during the years 2003-2008 is expected to be less than or equal to F_{OFL}. Consequently fishing mortality is believed to have an insignificant impact on stock sustainability. Under FMP 1, the stock is projected to sustain itself at or above MSST. Consequently change in biomass is believed to have an insignificant impact on stock sustainability. The direct effects of spatial/temporal concentration of catch on change in genetic integrity and reproductive success, and the indirect effects of both the change in prey availability and the change in habitat suitability are believed to have an insignificant impact on stock sustainability.

Status Determination from Modeling

Stock Size Relative to MSST

Under FMP 1, GOA Pacific ocean perch projected female spawning biomass for 2003 (B2003) of 113,000 mt is greater than $B_{35\%}$ and consequently the stock is projected to be above its MSST and not projected to be in an overfished condition. Projected female spawning biomass for 2005 (B2005) of 113,500 mt is greater than $B_{35\%}$ and consequently the stock is not projected to be approaching an overfished condition.

Age and Size Composition

GOA Pacific ocean perch are slow growing and long-lived (maximum age 84 years; mean age at recruitment, 10 years; Heifetz *et al.* 2002).

Under FMP 1, the age composition of GOA Pacific ocean perch could change under fishing pressure. For example, under FMP 1, the mean age of the GOA Pacific ocean perch in 2008, as computed in model projections, is 10.6 years. This compares with an estimated mean age in the equilibrium unfished GOA stock of 14.3 years. Note that the mean ages and sizes actually observed in 2008 will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of GOA Pacific ocean perch is 50:50, but females are generally larger than males. No information is available to suggest that sex ratio would change under FMP1, but size composition of GOA Pacific ocean perch might change in proportion to the change in age composition.

Cumulative Effects of FMP 1

Table 4.5-21 summarizes the cumulative effects analysis for GOA Pacific ocean perch.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific ocean perch stock is insignificant under FMP 1.

- **Persistent Past Effects.** Past effects on mortality are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA Pacific ocean perch and is rated as insignificant. Pacific ocean perch are fished at less than the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific ocean perch stock is expected to be insignificant under FMP 1.

- **Persistent Past Effects.** Past effects on the change in biomass level are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass level are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the Pacific ocean perch biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects on the change in genetic structure and reproductive success of GOA Pacific ocean perch are the same as those indicated for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in genetic structure and reproductive success of GOA Pacific ocean perch are the same as those indicated for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** It is determined that FMP 1 would have an insignificant effect on Pacific ocean perch prey availability.

- **Persistent Past Effects.** Past effects on the change in prey availability are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific ocean perch stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** It is determined that FMP 1 would have an insignificant effect on Pacific ocean perch habitat suitability.

- **Persistent Past Effects.** Past effects on the change in habitat suitability are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in habitat suitability are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Pacific ocean perch stock to sustain itself at or above MSST is jeopardized.

4.5.1.12 Thornyhead Rockfish

Numerous fishery management actions have been implemented that affect the thornyhead rockfish fisheries in the GOA. These actions are described in more detail in Section 3.5.1.23 of this Programmatic SEIS. Until recently, thornyhead rockfish were managed as its own stock under the GOA groundfish FMP under the Tier 3 management category; thus MSSTs are defined for these species by the National Standard Guidelines. Beginning in 2004, thornyhead rockfish will be managed under Tier 5. GOA thornyhead rockfish were modeled under the Tier 3 category for this analysis.

Direct/Indirect Effects of FMP 1

The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on GOA thornyhead rockfish. All of these potential effects are expected to be insignificant. The significance ratings are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The average fishing mortality imposed on the GOA thornyhead stock in 2002 is projected to be 0.032 under current management. Under FMP 1, fishing mortality is projected to decrease to 0.021 in 2003 and decrease further to 0.016 in 2007. These values are well below the F_{MSY} proxy value of 0.102 which is the rate associated with the OFL (Table H.4-37 of Appendix H). The impact of fishing mortality on GOA thornyhead rockfish is expected to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Total Biomass

Total (ages 5 through 55+) biomass of GOA thornyheads at the start of 2002 is estimated to be 54,000 mt. Model projections of future total GOA biomasses are shown in Table H.4-37 of Appendix H. Under FMP 1, model projections indicate that total GOA biomass is expected to remain at 54,000 mt by 2003, then slowly increase to a value of 56,000 mt by 2007, with a 2003-2007 average value of 55,000 mt. Because total biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spawning Biomass

Spawning biomass of female GOA thornyheads at the start of 2002 is estimated to be 23,500 mt. Model projections of future GOA spawning biomasses are shown in Table H.4-37 of Appendix H. Under FMP 1, model projections indicate that GOA spawning biomass is expected to increase to a value of 23,600 mt by 2003, and increasing to 24,600 mt by 2007, with a 2002-2007 average value of 24,100 mt. Because spawning

biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST, this effect would be insignificant under FMP 1.

Spatial/Temporal Concentration of Catch

Thornyhead catch is approximately evenly divided between longliners and trawlers under status quo management. There is nothing about FMP 1 that is expected to change this. Longline catches are spatially dispersed along the continental shelf break throughout the GOA (Figure 4.5-1) and temporally dispersed due to the nature of the Individual Fishing Quota (IFQ) sablefish fishery. For example, longline thornyhead catches in 2000 occurred year round, with peaks in April and September which did not exceed 60 mt per week. Trawler catch has been more concentrated in time, with some catches of 20-40 mt per week happening in late spring and a single large peak of 160 mt per week in 2000 during July, coincident with the rockfish trawl fishery. Figure 4.5-2. The distribution of thornyheads from surveys did not appear to change over the same time period (Figure 4.5-3). This apparent concentration may be the indirect result of changes in the trawl fisheries for deepwater flatfish and rockfish since thornyheads are not a primary target of trawl fisheries. However, it should be noted that the overall catch of thornyheads is low relative to both the estimated biomass and the ABC, such that this apparent concentration of catch is unlikely to have any adverse population effects. Therefore, this impact is expected to be insignificant, because the concentration of harvest would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Habitat Suitability

Under FMP 1, all current management measures would be maintained. The level of habitat disturbance expected under FMP 1 would not appear to affect the sustainability of thornyheads either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST. There is no indication that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP. Therefore, the effects of FMP 1 on thornyhead habitat suitability are expected to be insignificant, because future levels of habitat disturbance would not lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Prey Availability

In the GOA, shortspine thornyheads prey on benthic invertebrates; according to the AFSC food habits database, much of their diet in the 1990s has been composed of shrimp. Thornyheads are rare in the diets of other groundfish, birds, or marine mammals in the GOA according to the present limited information. Therefore, the effects of status quo federal groundfish fisheries on trophic interactions involving GOA thornyheads are expected to be minor. The current levels and distribution of groundfish harvest do not appear to impact prey availability for thornyheads such that it affects the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST. There is no indication that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 1. Therefore, this impact is expected to be insignificant because there is no evidence that future FMP 1 harvest levels or distribution of harvest would lead to a change in prey availability such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on GOA Thornyhead Rockfish

The GOA thornyhead stock appears to be healthy and stable under current management, and catches have generally been below the estimated ABCs because thornyheads are taken as bycatch in other directed fisheries. To the best of our knowledge, thornyheads are widely distributed in the deeper habitats of the GOA, where fishing impacts have historically been low. As long as catches remain at or near the currently observed low levels, as predicted under FMP 1, we do not expect any significant population effects to thornyheads.

Status Determination from Modeling

Stock Size Relative to MSST

The GOA thornyhead stock is not overfished. At 23,500 mt, spawning stock biomass is expected to be well above both $B_{35\%}$ level (14,681 mt) as well as the $B_{40\%}$ level (16,045 mt) in the year 2002 and will remain above $B_{40\%}$ in all projection years under FMP 1.

Age and Size Composition

Under FMP 1, the mean age of the GOA thornyhead stock in 2007, as computed in model projections (Table H.4-37 of Appendix H), is 10.23 years. This compares with a mean age in the equilibrium unfished GOA stock of 12.67 years.

Sex Ratio

The sex ratio of GOA thornyheads is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-22 summarizes the cumulative effects analysis for GOA thornyhead rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA thornyhead rockfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects include past foreign, JV, and domestic groundfish fisheries. The removals of thornyhead rockfish that occurred in these fisheries have had a lingering adverse effect on the populations. See Section 3.5.1.23 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause thornyhead rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of thornyhead rockfish. The IPHC longline fishery is

identified as a potential adverse contributor to thornyhead rockfish mortality since they are caught as bycatch in this fishery. However, the State of Alaska shrimp fishery is identified as a non-contributing factor since thornyhead rockfish bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA thornyhead rockfish and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** It is not expected that FMP 1 will result in a significantly adverse impact to these stocks.

- **Persistent Past Effects.** Past effects include past foreign, JV, and domestic groundfish fisheries. Past removals by these fisheries have had a lingering adverse effect on the GOA thornyhead rockfish populations. See Section 3.5.1.23 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause thornyhead rockfish mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the thornyhead rockfish biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.23 and 3.10. The IPHC longline fishery is identified as a potential adverse contributor to the thornyhead rockfish biomass level since they are caught as bycatch in this fishery. The State of Alaska shrimp fishery is identified as a non-contributing factor since thornyhead rockfish bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA thornyhead rockfish and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the GOA thornyhead rockfish. Climate changes and regime shifts have been identified as having a persistent past effect on the reproductive success of GOA thornyhead rockfish. Climate changes and regime shifts and corresponding water temperature variation could affect prey availability and

habitat suitability, which in combination could affect the reproductive success of the thornyhead rockfish stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of thornyhead rockfish due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA thornyhead rockfish. The IPHC longline fishery removals could be sufficiently concentrated as to alter the genetic structure and reproductive success of GOA thornyhead rockfish populations and is therefore identified as a potential adverse contributor. The State of Alaska shrimp fishery is identified as a non-contributing factor since bycatch of thornyhead rockfish is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the thornyhead rockfish catch and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the GOA thornyhead rockfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts. Climate changes and regime shifts and corresponding water temperature variation effect the availability of some prey species (i.e. shrimp); however, studies on benthic invertebrates have not been conducted.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA thornyhead rockfish stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The IPHC longline fishery is identified as a non-contributing factor since bycatch of GOA thornyhead rockfish prey species is not expected to occur in this fishery. The State of Alaska shrimp fishery is identified as a potential adverse contributor to prey availability since removal of shrimp, the main prey species of GOA thornyhead rockfish, occurs in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the GOA thornyhead rockfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for GOA thornyhead rockfish include climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA thornyhead rockfish stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fishery has been identified as a potential adverse contributor to GOA thornyhead rockfish habitat suitability. See Section 3.6.4 for information on the impacts of fishery gear on EFH. The State of Alaska shrimp fishery is identified as a non-contributing factor since habitat degradation by the shrimp fishery gear is not expected to occur.

- **Cumulative Effects.** A cumulative effect is identified for GOA thornyhead rockfish habitat suitability and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the thornyhead rockfish stock to sustain itself at or above the MSST is jeopardized.

4.5.1.13 Rockfish

At least 32 rockfish species of the genera *Sebastes* and *Sebastolobus* have been reported to occur in the GOA and BSAI (Eschmeyer *et al.* 1984), and several of these species are of commercial importance. Sections 3.5.1.12 and 3.5.1.24 describes rockfish in the BSAI and GOA in more detail.

BSAI Northern Rockfish – Direct/Indirect Effects of FMP 1

Until recently, northern rockfish, rougheye rockfish, and shortraker rockfish made up the other red rockfish assemblage in the BSAI. This group was managed under Tier 5 of Amendment 56 to the BSAI groundfish management plan. As of 2004, northern rockfish is managed separately under Tier 3, and shortraker/rougheye rockfish are managed under Tier 5. The other red rockfish group no longer exists. BSAI northern rockfish were modeled under the Tier 5 category for this analysis. The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on this group. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The catch of BSAI northern rockfish in 2003 was estimated as 6,400 mt. Projected catches from 2003-2008 are shown in Table H.4-15 in Appendix H. Under FMP 1, model projections indicate that the catch is expected to decrease to 5,400 mt in 2005, then increase to 5,600 mt in 2008. The 2003-2008 average catch is 5,800 mt. The impact of fishing mortality on BSAI northern rockfish is considered to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Reliable estimates of total and spawning biomass are not available for this species. Therefore, the potential impact of FMP 1 on biomass level is unknown, because the MSST cannot be determined.

Spatial/Temporal Concentration of Catch

Northern rockfish are caught as bycatch in the BSAI area, with much of the harvest occurring in the Aleutian Islands (Spencer and Reuter 2002). Model projections indicate that the average harvest of 5,800 mt from 2003-2008 occurs largely in the eastern Aleutian Islands (3,100 mt, 55 percent), with 1,260 mt (22 percent) occurring in the central Aleutians and 1,100 mt (18 percent) occurring in the western Aleutians. The harvest of northern rockfish in the Aleutian Islands is taken largely in the Atka mackerel fishery. The potential impact of FMP 1 is unknown, because evidence is insufficient to conclude whether the spatial and/or temporal concentration of harvest would lead to a detectable change in genetic diversity or reproductive success that would materially affect the stock's ability to sustain itself at or above the MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. There is no indication that existing habitat- mediated impacts would undergo significant qualitative change under FMP 1. Evidence is insufficient to conclude whether future levels of habitat disturbance would lead to a change in spawning or rearing success that would affect the ability of the stock to sustain itself at or above the MSST. Therefore, the potential effect of FMP 1 on habitat suitability for BSAI northern rockfish is unknown.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. There is no indication that trophic interactions would undergo significant qualitative change under FMP 1. Because evidence is insufficient to conclude whether future harvest levels and distribution of harvest would lead to a change in prey availability that would affect the stock's ability to sustain itself at or above the MSST, the potential effect of FMP 1 on prey availability for BSAI northern rockfish is unknown.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Northern Rockfish

An age-structured population model for BSAI northern rockfish is not available, and projections of future catch ABC and OFL levels were made by carrying over the 2002 baseline values into the future. Under these assumptions, BSAI northern rockfish are fished at less than the OFL and the effects of mortality under FMP are considered insignificant. Since the MSST cannot be calculated, the spatial/temporal distribution of catch and other direct/indirect effects are unknown.

Status Determination from Modeling

Stock Size Relative to MSST

The catch rates are below the ABC and OFL values for all years. The MSST has not been determined for this species.

Age and Size Composition

Age and size composition estimates are not available for this species.

Sex Ratio

The sex ratio of BSAI northern rockfish is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-23 summarizes the cumulative effects analysis for BSAI northern rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI northern rockfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI northern rockfish. See Section 3.5.1.12 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution; acute and/or chronic pollution events could cause northern rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of northern rockfish. The IPHC longline fishery is identified as a non-contributing factor since bycatch of BSAI northern rockfish is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI northern rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is rated as unknown since the MSST for this stock is not able to be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI northern rockfish. See Section 3.5.1.12 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause northern rockfish mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the northern rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.12 and 3.10. The IPHC longline fishery is identified as a non-contributing factor since bycatch of BSAI northern rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI northern rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

<u>Spatial/Temporal Concentration of Catch</u>

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine the MSST.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI northern rockfish. Climate changes and regime shifts are identified as having a potential beneficial/adverse effect on BSAI northern rockfish. See Section 3.5.1.12 and Section 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of northern rockfish due to climate changes and regime shifts are potentially beneficial or adverse. However, climate changes and regime shifts are not expected to be sufficient to alter the genetic sub-population structure of northern rockfish. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic sub-population structure and/or the reproductive success of BSAI northern rockfish. The IPHC longline fishery has been identified as a non-contributing factor to the genetic structure and reproductive success of the other rockfish species since bycatch of this species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the northern rockfish catch; however, this effect is unknown since the MSST is not possible to be determined.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI northern rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the change in prey availability of the BSAI northern rockfish stock. The actual effect of climate changes and regime shifts on northern rockfish prey availability is unknown, but could have had a potentially beneficial or adverse effect. See Sections 3.5.1.12 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI northern rockfish stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The IPHC longline fishery has been identified as a non-contributing factor since it is unlikely that bycatch of northern rockfish prey species occurs in this fishery. See Section 3.5.1.12 for more information on the trophic interactions of BSAI northern rockfish species.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI northern rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for BSAI northern rockfish include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potentially beneficial or adverse effect. The past foreign, JV, and domestic groundfish fisheries are identified as having a past adverse effect on habitat suitability, largely due to the intense bottom trawling that has occurred in northern rockfish species habitat. The IPHC longline fishery has also been identified as having had an adverse effect on northern rockfish species habitat suitability, possibly having disrupted northern rockfish species spawning and/or rearing habitats. See Section 3.5.1.12 for more information on the past events that have affected northern rockfish habitat suitability.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI northern rockfish stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fisheries have also been identified as having a potential adverse effect on the northern rockfish habitat suitability. These fisheries are expected to continue into the future and could disrupt northern rockfish species spawning and/or rearing habitats.

- **Cumulative Effects.** A cumulative effect is possible for the change in habitat suitability; however, the effect is unknown since the MSST is unable to be determined. It is unknown whether the combined effects will make the northern rockfish species vulnerable to spawning and rearing habitat disturbances due to fishing gear.

BSAI Shortraker/Rougheye Rockfish – Direct/Indirect Effects of FMP 1

As stated above, until recently, rougheye and shortraker rockfish made up the other red rockfish assemblage in the BSAI. These species now make up their own group and are managed under Tier 5. The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on this group. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The catch of BSAI shortraker/rougheye rockfish in 2003 was estimated as 800 mt. Projected catches from 2003-2008 are shown in Table H.4-16 in Appendix H. Under FMP 1, model projections indicate that the catch is expected to range between 700 and 900 mt between 2003 and 2008, with an average catch of 800 mt. The impact of fishing mortality on BSAI shortraker/rougheye rockfish is considered to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Reliable estimates of total and spawning biomass are not available for these stocks. Therefore, the potential impact of FMP 1 on biomass level is unknown, because the MSST cannot be determined.

Spatial/Temporal Concentration of Catch

Shortraker/rougheye rockfish are caught as bycatch in the BSAI area, with much of the harvest occurring in the Aleutian Islands (Spencer and Reuter 2002). Model projections indicate that the average harvest of 800 mt from 2003-2008 occurs evenly throughout the Aleutians Islands, with between 27 percent-31 percent occurring in each of the Aleutian Islands subareas. The harvest of shortraker/rougheye rockfish in the Aleutian Islands is taken in the Pacific ocean perch and Pacific cod longline fisheries. The potential impact of FMP 1 is unknown, because evidence is insufficient to conclude whether the spatial and/or temporal concentration of harvest would lead to a detectable change in genetic diversity or reproductive success that would materially affect the stock's ability to sustain itself at or above the MSST.

Habitat Suitability

Any habitat-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. There is no indication that existing habitat- mediated impacts would undergo significant qualitative change under FMP 1. Evidence is insufficient to conclude whether future levels of habitat disturbance would lead to a change in spawning or rearing success that would affect the ability of the stock to sustain itself at or above the MSST. Therefore, the potential effect of FMP 1 on habitat suitability for BSAI shortraker/rougheye rockfish is unknown.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 1 would be governed by a complex web of direct and indirect interactions which are difficult to quantify. There is no indication that trophic interactions would undergo significant qualitative change under FMP 1. Because evidence is insufficient to conclude whether future harvest levels and distribution of harvest would lead to a change in prey availability that would affect the stock's ability to sustain itself at or above the MSST, the potential effect of FMP 1 on prey availability for BSAI shortraker/rougheye rockfish is unknown.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Shortraker/Rougheye Rockfish

An age-structured population model is not available for either BSAI shortraker or rougheye rockfish, and projections of future catch ABC and OFL levels were made by carrying over the 2002 baseline values into the future. Under these assumptions, BSAI shortraker/rougheye rockfish are fished at less than the OFL and the effects of mortality under FMP 1 are considered insignificant. Since the MSST cannot be calculated, the spatial/temporal distribution of catch and other direct/indirect effects are unknown.

Status Determination from Modeling

Stock Size Relative to MSST

The catch rates are below the ABC and OFL values for all years. MSSTs have not been determined for these stocks.

Age and Size Composition

Age and size composition estimates are not available for these stocks.

Sex Ratio

The sex ratio of BSAI shortraker/ rougheye rockfish is assumed to be 50:50. No information is available to suggest that this would change under FMP 1.

Cumulative Effects of FMP 1

Table 4.5-24 summarizes the cumulative effects analysis for BSAI shortraker/rougheye rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI shortraker/rougheye rockfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI shortraker/rougheye rockfish. See Section 3.5.1.13 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shortraker/rougheye rockfish. The IPHC longline fishery and the State of Alaska shrimp fishery are identified as non-contributing factors since bycatch of BSAI shortraker/rougheye rockfish is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI shortraker/rougheye rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is rated as unknown since the MSST for this stock is not able to be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had an adverse persistent past effect on BSAI shortraker/rougheye rockfish. See Section 3.5.1.13 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to potential adverse effects of marine pollution; acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the shortraker/rougheye rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.13 and 3.10. The IPHC longline fishery and the State of Alaska shrimp fishery are identified as a non-contributing factors since bycatch of BSAI shortraker/rougheye rockfish species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI shortraker/rougheye rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine the MSST.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI shortraker/rougheye rockfish. Climate changes and regime shifts are identified as having a potential beneficial/adverse effect on BSAI shortraker/rougheye rockfish. See Section 3.5.1.13 and Section 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of shortraker/rougheye rockfish due to climate changes and regime shifts are potentially beneficial or adverse. However, climate changes and regime shifts are not expected to be sufficient to alter the genetic sub-population structure of shortraker/rougheye rockfish. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic sub-population structure and/or the reproductive success of BSAI shortraker/rougheye rockfish. The IPHC longline fishery and State of Alaska shrimp fishery have been identified as non-contributing factors to the genetic structure and reproductive success of the other rockfish species since bycatch of this species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the shortraker/rougheye rockfish catch, but the effect is unknown since the MSST is not possible to be determined.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI shortraker/rougheye rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the change in prey availability of the BSAI shortraker/rougheye rockfish stock. The actual effect of climate changes and regime shifts on shortraker/rougheye rockfish prey availability is unknown, but could have had a potentially beneficial or adverse effect. See Sections 3.5.1.13 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI shortraker/rougheye rockfish stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The IPHC longline fishery has been identified as a non-contributing factor since it is unlikely that bycatch of shortraker/rougheye rockfish prey species occurs in this fishery. The State of Alaska shrimp fishery is identified as a potential adverse contributor to BSAI shortraker/rougheye prey availability since shrimp is one of the main prey species of rougheye rockfish. See Section 3.5.1.13 for more information on the trophic interactions of BSAI shortraker/rougheye rockfish species.

- **Cumulative Effects.** A cumulative effect is possible for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI shortraker/rougheye rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for BSAI shortraker/rougheye rockfish include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potentially beneficial or adverse effect. The past foreign, JV, and domestic groundfish fisheries are identified as having a past adverse effect on habitat suitability, largely due to the intense bottom trawling that has occurred in shortraker/rougheye rockfish species habitat. The IPHC longline fishery has also been identified as having had an adverse effect on shortraker/ rougheye rockfish species habitat suitability, possibly having disrupted shortraker/rougheye rockfish species spawning and/or rearing habitats. The State of Alaska shrimp fishery is identified as a non-contributing factor to shortraker/rougheye rockfish habitat suitability since habitat degradation by shrimp fishery gear is not expected to occur. See Section 3.5.1.13 for more information on the past events that have affected shortraker/rougheye rockfish habitat suitability.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI shortraker/rougheye rockfish stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fisheries have also been identified as having a potential adverse effect on the shortraker/rougheye rockfish habitat suitability. These fisheries are expected to continue into the future and could disrupt shortraker/rougheye rockfish species spawning and/or rearing habitats.

- **Cumulative Effects.** A cumulative effect is possible for the change in habitat suitability; however, the effect is unknown since the MSST is unable to be determined. It is unknown whether the combined effects will make the shortraker/rougheye rockfish species vulnerable to spawning and rearing habitat disturbances due to fishing gear.

BSAI Other Rockfish – Direct/Indirect Effects of FMP 1

Twenty-nine species are included in the BSAI other rockfish assemblage (see Section 3.5.1.14), but they are dominated in abundance by the light dusky rockfish and shortspine thornyheads. Currently, this complex is assumed to be two separate stocks in the EBS and Aleutian Islands regions and is assessed as such. The BSAI other rockfish assemblage falls under Tier 5 of Amendment 56 of the BSAI groundfish FMP, relying on biomass estimates to determine ABC and OFL values. The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on this group. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The catch of Aleutian Islands other rockfish in 2003 was estimated as 300 mt, ranging between 200 mt and 300 mt from 2003 to 2008. In the EBS, the projected harvest was 100 mt in each projection year. Projected

catches from 2003-2008 are shown in Tables H.4-13 and H.4-14 in Appendix H. The 2003 OFL for this species complex is 846 mt and 1,280 mt in the Aleutian Islands and EBS, respectively (Reuter and Spencer 2002). Fishing mortality at projected levels is well below the OFL for other rockfish, so FMP 1 is not likely to jeopardize the capacity of the stock to produce MSY on a continuing basis. Therefore, this impact is considered insignificant.

When species are managed as complexes rather than individual species, more abundant species may be disproportionately exploited and thus suffer higher mortality. For example, Reuter and Spencer (2002) recommended that light dusky rockfish be split out of the other rockfish group and assigned a separate ABC. Their findings indicate that light dusky rockfish make up a large amount of the other rockfish catch in the Aleutian Islands and may be disproportionally exploited. Furthermore, Reuter and Spencer (2002) have recommended that EBS and Aleutian Islands biomass estimate for light dusky rockfish be combined for the BSAI. This recommendation comes in light of new catch and survey distribution maps which show continuous spatial distribution of light dusky rockfish along the Aleutian Islands and EBS slope.

Change in Biomass Level

Estimates of total and spawning biomass are not available for these species. Therefore, the potential impact of FMP 1 on biomass level is unknown, because the MSST cannot be determined.

Spatial/Temporal Concentration of Catch

Species included in the other rockfish category are caught as bycatch in the BSAI area, with much of the harvest occurring in the Aleutian Islands (Reuter and Spencer 2002). In the Aleutian Islands, 89 percent of the average harvest of 300 mt occurs largely in the western and central Aleutian Islands, taken largely in the Atka mackerel trawl fishery and the sablefish longline fishery. In the EBS, the average catch of 100 mt is taken largely in the Pacific cod bottom trawl fishery, and the sablefish and Greenland turbot longline fisheries. Information is insufficient to determine whether existing harvest patterns would undergo any significant change under FMP 1. Consequently, the potential impact of FMP 1 is unknown, because evidence is insufficient to conclude whether the spatial and/or temporal concentration of harvest would lead to a detectable change in genetic diversity or reproductive success that would materially affect the stock's ability to sustain itself at or above the MSST.

Habitat Suitability

Any habitat suitability impacts of FMP 1, such as adverse effects to spawning habitat, nursery grounds, and benthic structures, as a result of commercial fishing would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Evidence is insufficient to conclude whether future levels of habitat disturbance would lead to a change in spawning or rearing success that would affect the ability of the stock to sustain itself at or above the MSST. Therefore, the potential effect of FMP 1 on habitat suitability for BSAI shortraker/rougheye rockfish is unknown.

Prey Availability

As with habitat related impacts, any effects of FMP 1 on predator-prey relationships would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Information is insufficient

to conclude that such trophic interactions would undergo any significant change from the current condition. Because evidence is insufficient to conclude whether future harvest levels and distribution of harvest would lead to a change in prey availability that would affect the stock's ability to sustain itself at or above the MSST, the potential effect of FMP 1 on prey availability for BSAI shortraker/rougheye rockfish is unknown.

Summary of Direct and Indirect Effects of FMP 1 on BSAI Other Rockfish

An age-structured population model is not available for either Aleutian Islands or EBS other rockfish, and projections of future catch ABC and OFL levels were made by carrying over the 2002 baseline values into the future. Under these assumptions, other rockfish are fished at less than the ABC in each area, and the direct and indirect effects under FMP 1 are considered either insignificant or unknown. The spatial/temporal distribution of catch should have no significant direct impact on stock productivity.

Status Determination from Modeling

Stock Size Relative to MSST

The F is below the ABC and OFL values for the other rockfish complex. MSSTs have not been determined for these species.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

The estimated sex ratio is not available for these species.

Cumulative Effects of FMP 1

Table 4.5-25 summarizes the cumulative effects analysis for BSAI other rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI other rockfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Past effects on mortality are the same as those described for BSAI shortraker/rougheye rockfish under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI shortraker/rougheye rockfish under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI other rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The

combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is rated as unknown since the MSST for this stock complex is not able to be determined.

- **Persistent Past Effects.** Past effects on the change in biomass are the same as those described for BSAI shortraker/rougheye rockfish under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are the same as those described for BSAI shortraker/rougheye rockfish under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI other rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine.

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI other rockfish catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success and genetic structure of other rockfish are the same as those described for shortraker/rougheye rockfish under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the other rockfish catch; however, this effect is unknown since the MSST is not possible to be determined.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI other rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects on the change in prey availability of other rockfish are the same as those described for shortraker/rougheye rockfish under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability of other rockfish are the same as those described for shortraker/rougheye rockfish under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI other rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects on the change in habitat suitability of other rockfish are the same as those described for shortraker/rougheye rockfish under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in habitat suitability of other rockfish are the same as those described for shortraker/rougheye rockfish under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in habitat suitability; however, the effect is unknown since the MSST is unable to be determined. It is unknown whether the combined effects will make the other rockfish species vulnerable to spawning and rearing habitat disturbances due to fishing gear.

GOA Northern Rockfish – Direct/Indirect Effects of FMP 1

Tier 3a is used to compute the ABC and OFL values for northern rockfish. Northern rockfish are combined with other slope rockfish in the eastern GOA (Heifetz *et al.* 2002). The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on GOA northern rockfish. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality and Change in Biomass Level

Average projected catch under FMP 1 is only 49 percent of projected ABC during the years 2003 to 2008. Consequently, average catch under FMP 1 would likely be higher (average catch of 71 percent of projected ABC) during the years 2003 - 2008. Spawning biomass, fishing mortality, vulnerable biomass, and implied SPR rates would also change relative to an average catch of 71 percent of ABC during the years 2003 to 2008. However, average fishing mortality during the years 2003 to 2008 is still expected to be less than F_{OFL} (0.066). A lack of recent strong year-classes to the age structured model for GOA northern rockfish also leads to the projected ABC and catch decreasing with time, which is adequately represented in the projection model (Table H.4-35 of Appendix H). The impact of fishing mortality on GOA northern rockfish is considered to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis. The potential impact of FMP 1 on GOA northern biomass levels is also expected to be insignificant, because total and spawning biomass would tend toward levels that would maintain the ability of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

Under FMP 1, GOA northern rockfish are taken in the central (89 percent of GOA northern rockfish captured) and the western (11 percent) GOA, primarily in directed rockfish bottom trawl fisheries (60 percent of GOA northern rockfish captured) and as bycatch in Pacific ocean perch bottom trawl fisheries (22 percent).

The ABC for northern rockfish is determined for the entire GOA and then geographically apportioned among management areas. This apportionment spreads fishery effort over the GOA in an effort to reduce the risk of localized depletion. However, the majority of EBS and GOA northern rockfish commercial catches have historically come from the same localized geographic regions year after year. The largest GOA commercial catches occurred in one area known as the Snakehead which accounted for 45.8 percent of all GOA northern rockfish catches from 1990-1998 (Clausen and Heifetz, in preparation). Similarly, the largest EBS commercial catches occurred in one area known as the Zhemchug Canyon which accounted for 57.05 percent of all EBS northern rockfish catches from 1990-1998 (Clausen and Heifetz, in preparation). Aleutian Islands northern rockfish commercial catches were also concentrated in several geographic regions, but there was no single localized aggregation that dominated the catch year after year. Based upon these highly localized catches, northern rockfish are not believed to be highly mobile or migratory as adults and there may be a potential for localized depletion of this stock even with apportionment among management areas.

Northern rockfish catches in the GOA are largely taken in directed rockfish fisheries and are highly localized in areas away from the proposed Steller sea lion prey species closures found in FMP 1.

Under FMP 1, the northern rockfish trawl fishery would be managed as under the current GOA FMP which has an open season that occurs in July and generally lasts a few weeks. The open fishery system compresses the fishery effort into a short time period and creates difficulty for the management of the fishery by increasing the risk of possible overfishing if the fishery is not closed before catch exceeds ABC.

This impact is expected to be insignificant; the concentration of harvest would not be sufficient to alter the genetic sub-population structure or reproductive success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Habitat Suitability

Under FMP 1, bottom trawling or other fishing gear in contact with the ocean floor on the GOA continental shelf or upper slope could adversely impact juvenile northern rockfish habitat. Juvenile northern rockfish tend to live inshore in shallower depths than adults which are captured primarily between 75 to 175 m. Juvenile northern rockfish may also be associated with epifauna that provides structural relief such as corals or sponges. If so, damage to this epifauna by bottom trawls may reduce survival of juvenile fish.

FMP 1 closes the eastern GOA to trawling. However, the eastern GOA contains less than one percent of the GOA biomass of northern rockfish (Heifetz *et al.* 2002). Consequently, this closure probably has little effect on the GOA stock of northern rockfish.

The effects of FMP 1 on habitat suitability for GOA northern rockfish are expected to be insignificant because future levels of habitat disturbance would not lead to a detectable change in spawning or rearing success such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Prey Availability

The major prey of northern rockfish is euphausiids, and northern rockfish may in turn be preyed upon by large piscivorous fish. There is no indication that existing trophic interactions would undergo significant qualitative change under FMP 1. Therefore, this impact is expected to be insignificant, because there is no evidence that future FMP 1 harvest levels or distribution of harvest would lead to a change in prey availability such that it would jeopardize the ability of the stock to sustain itself at or above the MSST.

Summary of Direct and Indirect Effects of FMP 1 on GOA Northern Rockfish

The comparative baseline for effects on GOA northern rockfish is the impact on stock sustainability as indexed by projection model estimates of fishing mortality relative to overfishing limits (F_{OFL}) and by projection model estimates of female spawning stock biomass relative to the MSST.

Under FMP 1, average fishing mortality during the years 2003 - 2008 is expected to be less than or equal to F_{OFL}. Consequently, fishing mortality is believed to have an insignificant impact on stock sustainability. Under FMP 1, the stock is projected to sustain itself at or above MSST. Consequently, change in biomass is believed to have an insignificant impact on stock sustainability. Additionally, because the stock is projected to sustain itself at or above MSST, the direct effects of spatial/temporal concentration of catch on change in genetic integrity and reproductive success, as well as the indirect effects of both the change in prey availability and the change in habitat suitability, are believed to have an insignificant impact on stock sustainability.

Status Determination from Modeling

Stock Size Relative to MSST

Under FMP 1, GOA northern rockfish projected female spawning biomass for 2003 (B2003) of 42,700 mt is greater than $B_{35\%}$. Thus, the stock is projected to be above its MSST and is not projected to be in an overfished condition. Projected female spawning biomass for 2005 (B2005) of 39,100 mt is greater than $B_{35\%}$; consequently, the stock is not projected to be approaching an overfished condition.

Age and Size Composition

Under FMP 1, the age composition of GOA northern rockfish could change under fishing pressure. For example, under FMP 1 the mean age of the GOA northern rockfish in 2008, as computed in model projections, is 11.2 years. This compares with a mean age in the equilibrium unfished GOA stock of 12.6 years. Note that the mean ages and sizes actually observed in 2008 will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of GOA northern rockfish is 50:50. No information is available to suggest that sex ratio would change under FMP 1, but size composition of GOA northern rockfish might change in proportion to the change in age composition.

Cumulative Effects of FMP 1

Table 4.5-26 summarizes the cumulative effects analysis for GOA northern rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA northern rockfish stock is insignificant under FMP 1.

- **Persistent Past Effects.** Past effects of the foreign fisheries for the GOA northern rockfish stock. Include large removals, which appear to have a lingering effect on the populations (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch in this fishery has already been accounted for by domestic groundfish management. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to northern rockfish mortality.

- **Cumulative Effects.** A cumulative effect under FMP 1 is identified for mortality of GOA northern rockfish and is rated as insignificant. Northern rockfish are fished at less than the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA northern rockfish stock is expected to be insignificant under FMP 1.

- **Persistent Past Effects.** Past effects of the foreign fisheries for the GOA northern rockfish stock. Include large removals, which appear to have a lingering effect on the populations (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch in this fishery has already been accounted for by domestic groundfish management. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is

jeopardized. Climate changes and regime shifts are identified as making beneficial or adverse contributions to northern rockfish change in biomass levels as a function of change in reproductive success.

- **Cumulative Effects.** A cumulative effect is identified for change in biomass and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the northern rockfish biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure. However, there are lingering past effects due to climate changes and regime shifts (see Section 3.5.1.24) for change in reproductive success.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch in this fishery has already been accounted for by domestic groundfish management and is not expected to contribute to changes in genetic structure or reproductive success of northern rockfish. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as potentially beneficial or adverse contributors to reproductive success since changes in climate can affect prey availability and/or habitat suitability which in turn can affect recruitment. The magnitude and direction of the change in reproductive success with water temperatures is currently unknown. Climate changes and regime shifts are not considered to be contributors to change in genetic structure.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** It is determined that FMP 1 would have an insignificant effect on northern rockfish prey availability.

- **Persistent Past Effects.** Past climate changes and regime shifts are likely to have had lingering effects (both benficial and adverse) on northern rockfish prey species (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since northern rockfish prey species bycatch is not expected to occur. Climate changes and regime shifts are identified as making potentially beneficial or adverse contributions on prey availability, although the magnitude and the direction of change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to decrease prey availability such that the northern rockfish stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** It is determined that FMP 1 would have an insignificant effect on northern rockfish habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA northern rockfish stocks include past foreign, JV, and domestic fisheries, IPHC longline fishery and climate changes and regime shifts (see Section 3.5.1.24). Intense bottom trawling on northern rockfish habitat in the past likely disrupted spawning and/or rearing habitats in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts. The IPHC longline fisheries have also been identified as having adverse effects on northern rockfish habitat, although these effects are not expected to have been as intense as those effects associated with trawl gear (see Section 3.6.4 for additional information on the effects of trawling on benthic habitat). Climate changes and regime shifts have had both beneficial and adverse effects on northern rockfish habitat.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has been identified as an adverse contributing factor since the fishery gear could disrupt spawning and/or rearing habitats. Although, as stated above, the impacts associated with longline gear are not as significant as those associated with trawl gear. Impacts on habitat from climate changes and regime shifts on the GOA northern rockfish stock are identified as potentially beneficial or adverse contributors, although the magnitude and direction of the change are unknown in relation to strong and weak Aleutian Low systems. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the northern rockfish stock to sustain itself at or above MSST is jeopardized.

GOA Shortraker/Rougheye Rockfish – Direct/Indirect Effects of FMP 1

Shortraker/rougheye and other slope rockfish groups are placed in Tier 4 and 5. The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on GOA shortraker/rougheye rockfish. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The model projections for catch of shortraker/rougheye show relatively constant catches of about 1,000 mt over the years 2003-2007 (Table H.4-34 of Appendix H). These projected catches are less than would be expected if the present management policies were to remain in place, which this FMP assumes. ABC for shortraker/rougheye in the model (1,600 mt) is virtually the same as that for the fishery in the years 1997-2002 (ABCs of 1,590-1,730 mt, depending on the year), but catches in the fishery have averaged 1,602 mt over this period versus the 1,000 mt projected in the model. The reason for the lower-than-expected catch projections in the model for this FMP is uncertain. The impact of fishing mortality on GOA shortraker/rougheye rockfish is considered to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

No projections are possible for these two parameters, as shortraker/rougheye are classified as Tier 4 or Tier 5 species, with insufficient information to compute either parameter. Therefore, the potential impact of FMP 1 on biomass level is unknown, because the MSST cannot be determined.

Spatial/Temporal Concentration of Catch

The ABCs are geographically apportioned amongst the major management areas of the GOA which helps to spread out the catch and reduces the risk of localized depletion of the resource. Recent genetic studies of shortraker and rougheye rockfish indicate that there is stock structure for each species in the GOA, but additional research is needed for further verification and to better define the geographic extent of this structure. Until more information is available on this possible stock structure, there is a possibility that localized depletion may be occurring, despite the effort of geographic apportionment.

Shortraker/rougheye are to be taken only as bycatch in the GOA. The bycatch of these two species is taken in both bottom trawl and longline fisheries; the annual proportion caught by bottom trawl is usually a little higher than that caught by longline. The sablefish and halibut longline fisheries, in which shortraker/ rougheye are taken as bycatch, have been IFQ fisheries since 1995. As a result, these two fisheries have been open concurrently between March 15 and November 15 each year, which spreads out the catch of shortraker/rougheye over this entire eight month period. In contrast, bottom trawl fisheries that catch shortraker/rougheye are much shorter in duration, and are usually open for only a few weeks per year. This compresses the shortraker/rougheye trawl catch into a relatively short time period and may cause a greater risk of possible overfishing, because it is difficult to manage the TAC within this short time span.

The potential impact of FMP 1 is unknown, because evidence is insufficient to conclude whether the spatial and/or temporal concentration of harvest would lead to a detectable change in genetic diversity or reproductive success that would materially affect the stock's ability to sustain itself at or above the MSST.

Habitat Suitability

This FMP may beneficially affect habitat for shortraker/rougheye because it closes the eastern GOA to trawling. This closure prevents damage to the benthic environment in the eastern GOA because bottom trawls cannot be used. Although little is known about the habitat preferences of shortraker/rougheye, an undamaged benthic habitat may provide a benefit to these species. For example, observations from a manned submersible in the eastern GOA have found shortraker and/or rougheye rockfish associated with boulders along steep slopes (Krieger and Ito 1999) and with colonies of Primnoa coral (Krieger and Wing 2002). The eastern GOA trawl closure presumably causes a reduction in the alteration or destruction of these habitats, which may have a beneficial effect on shortraker/rougheye in this region. However, evidence is insufficient to conclude whether future levels of habitat disturbance would lead to a change in spawning or rearing success that would affect the ability of the stock to sustain itself at or above the MSST. Therefore, the potential effect of FMP 1 on habitat suitability for shortraker/rougheye is unknown.

Prey Availability

The major prey of adult rougheye rockfish in Alaska appears to be shrimp (Yang 1993 and 1996; Yang and Nelson 2000). Food habit information for shortraker rockfish is very limited, but the sparse data available at present indicate that squid, myctophids, and shrimp are the major items consumed (Yang 1993 and 1996; Yang and Nelson 2000). Pacific cod, and to a lesser extent walleye pollock, are also species that are known to prey on shrimp, so any changes in their abundance as a result of FMP 1 hypothetically could affect the food supply of shortraker/rougheye. To protect Steller sea lions, FMP 1 has two measures that may reduce the catch and increase the abundance of Pacific cod and walleye pollock: fishing closures around sea lion rookeries, and a $B_{20\%}$ fishing rule for two species. However, whether a change in abundance of Pacific cod or walleye pollock would actually affect the food supply for shortraker/rougheye is unknown, as there is no quantitative information on trophic interactions between all these species. Moreover, shortraker and rougheye rockfish reside in deeper depths than Pacific cod or walleye pollock, so they may not be competing for the same spatial aggregations of food.

There is no documentation of predation on either shortraker or rougheye rockfish. Consequently, it is not possible to determine how changes in predator abundance as a result of FMP 1 would affect these rockfish. Presumably, larger fishes such as Pacific halibut that are known to prey on other rockfish may also prey on rougheye rockfish, but adult shortraker rockfish are so large that they probably have few predators. Predator effects would likely be more important on juveniles of either species.

Because evidence is insufficient to conclude whether future harvest levels and distribution of harvest would lead to a change in prey availability that would affect the stock's ability to sustain itself at or above the MSST, the potential effect of FMP 1 on prey availability for shortraker/rougheye is unknown.

Summary of Direct and Indirect Effects of FMP 1 on GOA Shortraker/Rougheye Rockfish

The effects of FMP 1 on shortraker/rougheye in the GOA are summarized in Table 4.5-83. The effect of FMP 1 on these species through direct mortality from fishing is expected to be insignificant. All other potential direct and indirect effects of FMP 1 on this group are unknown.

Status Determination from Modeling

Stock Size Relative to MSST

The catch rates are below the ABC and OFL values for all years. The MSST has not been determined.

Age and Size Composition

No projections are possible for these two parameters, as shortraker/rougheye are classified as Tier 4 or Tier 5 species, with insufficient information to compute either parameter.

Sex Ratio

There is no information on the sex ratio of shortraker/rougheye, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 1 is unknown.

Cumulative Effects of FMP 1

Table 4.5-27 summarizes the cumulative effects analysis for GOA shortraker/rougheye rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA shortraker/rougheye rockfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had an adverse persistent past effect on GOA shortraker/rougheye rockfish stocks. See Section 3.5.1.24 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shortraker/rougheye rockfish. The IPHC longline fishery and State of Alaska shrimp fishery are identified as non-contributing factors since bycatch of rockfish species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA shortraker/rougheye rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is unknown since the MSST for this stock is not able to be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA shortraker/rougheye rockfish stocks. See Section 3.5.1.24 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the shortraker/rougheye rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.24 and 3.10. The IPHC longline fishery and State of Alaska shrimp are identified as non-contributing factors to GOA slope rockfish biomass level since bycatch is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA shortraker/rougheye rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal concentration of catch under FMP 1 is unknown.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA shortraker/rougheye rockfish; however, climate changes and regime shifts have been identified as having had potentially beneficial or adverse effects on shortraker/rougheye rockfish reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability, which in combination effect reproductive success. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to GOA shortraker/rougheye rockfish genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in

reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, they could affect reproductive success by driving changes in prey availability and habitat suitability. The IPHC longline fishery and the State of Alaska shrimp fishery are identified as non-contributing factors to the change in genetic structure and reproductive success of GOA shortraker/rougheye rockfish since bycatch in these fisheries is unlikely to occur.

- **Cumulative Effects.** A cumulative effect of the spatial/temporal characteristics of the GOA shortraker/rougheye rockfish complex is possible; however, the effect is unknown. It is unknown whether the combined effect of internal and external removals will occur in a localized manner such that it will lead to a detectable reduction in genetic diversity and reproductive success of the GOA shortraker/rougheye rockfish complex.

Change in Prey Availability

- **Direct/Indirect Effects.** The change in prey availability under FMP 1 is unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on shortraker/rougheye rockfish prey availability. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to shortraker/rougheye rockfish prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potentially beneficial or adverse contributors to prey availability. See Sections 3.5.1.24 and 3.10 for more information. The IPHC longline fishery is identified as a non-contributing factor to shortraker/rougheye rockfish prey availability since bycatch of shortraker/rougheye rockfish prey species is not expected to occur in this fishery. The State of Alaska shrimp fishery is identified as a potential adverse contributor to shortraker/rougheye rockfish prey availability since shrimp is a main prey item of rougheye rockfish.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA shortraker/rougheye rockfish; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The change in habitat suitability is determined to be unknown under FMP 1.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries, and the IPHC longline fisheries have been identified as having past persistent adverse effects on GOA shortraker/rougheye rockfish habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA shortraker/rougheye rockfish habitat suitability. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potentially beneficial or adverse contribution to shortraker/rougheye rockfish habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts. The IPHC longline fishery has been identified as a potential adverse contributor to shortraker/rougheye rockfish habitat suitability due to impacts from fishery gear. The State of Alaska shrimp fishery is a non-contributing factor since habitat degradation from shrimp fishery gear is not expected to occur. See Section 3.6.4 for more information on the impacts of fishery gear on EFH.

- **Cumulative Effect.** Although a cumulative effect is possible for habitat suitability of GOA shortraker/rougheye rockfish, the effect is currently unknown due to lack of scientific information.

GOA Slope Rockfish – Direct/Indirect Effects of FMP 1

Other slope rockfish groups are placed in Tier 5 where ABC is determined by F = 0.75M. Sharpchin rockfish are assessed under Tier 4 where OFL is calculated by F = M. The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on this group. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

A measure in this FMP that has a major influence on protecting slope rockfish species from over-harvest is the fact that under FMP 1, the eastern GOA is closed to all trawling. Trawl surveys show the biomass for all species of slope rockfish in the GOA is concentrated in the eastern GOA (Heifetz *et al.* 2002). Because most species of slope rockfish are only taken in trawls and not caught in other gear types such as longlines or traps, the eastern GOA trawl closure creates a *de facto* refugium in which most of the GOA population of slope rockfish is protected from any fishing pressure.

The model projections for catch of slope rockfish show relatively constant catches of about 700 mt in the years 2003-2007. These catches are similar to those seen in recent past years, so the projections for catch appear to be reasonable (Table H.4-31 of Appendix H). The impact of fishing mortality on GOA slope rockfish is considered to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

No projections are possible for these two parameters, as slope rockfish species are classified as Tier 4 or Tier 5 fish, with insufficient information to compute either total or spawning biomass or the MSST. Therefore, the potential impact of FMP 1 on biomass level is unknown.

Spatial/Temporal Concentration of Catch

The ABCs are geographically apportioned amongst the major management areas of the GOA which helps to spread out the catch over the GOA and reduces the risk of localized depletion of the resource. There have been no studies to determine stock structure for any species of slope rockfish, and it is unknown if

subpopulations exist. Consequently, there is a possibility that localized depletion may be occurring, despite the effort of geographic apportionment. However, because most of the biomass of slope rockfish occurs in the eastern GOA, which is closed to trawling in this FMP, localized depletion is unlikely under this FMP.

There are no measures in FMP 1 for IFQs or cooperatives for rockfish trawlers, who historically have taken most of the catch of slope rockfish in the form of bycatch. Because these measures do not exist in this FMP, rockfish trawl fisheries in the GOA in past years have only been open for a few weeks in July. This greatly compresses the catch into a short time period and has caused a greater risk of possibly overfishing slope rockfish, because it is difficult to manage the fishery within this short time span.

The potential impact of FMP 1 on GOA slope rockfish is unknown, because evidence is insufficient to conclude whether the spatial and/or temporal concentration of harvest would lead to a detectable change in genetic diversity or reproductive success that would materially affect the stock's ability to sustain itself at or above the MSST (which has not been determined for these stocks).

Habitat Suitability

This FMP greatly impacts habitat for slope rockfish because it closes the eastern GOA to trawling. This creates a *de facto* no-take zone or refugium for slope rockfish in this area, as trawls are generally the only effective gear for capturing most of these species. As noted above, nearly all the biomass of slope rockfish is found in the eastern GOA, which means the trawl closure in this region protects most of the GOA population from any fishing pressure. Use of refugia as a conservation measure could be particularly effective for rockfish species, as most rockfish are generally believed to be sedentary in nature and not undergo extensive migrations. The closed areas may allow increased survival of larger and older fish that produce significantly more eggs and larvae to replenish the GOA population. The trawl closure also prevents damage to the benthic environment in the eastern GOA because bottom trawls cannot be used. Although little is known about the habitat preferences of slope rockfish, an undamaged benthic habitat likely provides a benefit to these species. Juvenile slope rockfish may also be associated with epifauna such as corals or sponges that provide structural relief on the bottom. Prevention of possible damage by bottom trawls to corals and other "living substrates" may increase the amount of protective cover available to slope rockfish to escape predation, increase survival of juvenile fish and thus have a beneficial impact on the stocks. On balance, however, evidence is insufficient to conclude whether, or to what extent, future levels of habitat protection would lead to a change in spawning or rearing success that would measurably affect the ability of the GOA slope rockfish stock to sustain itself at or above the MSST (which has not been determined for these stocks). Therefore, the potential effect of FMP 1 on habitat suitability for this group must be considered unknown.

Prey Availability

No studies have been done in Alaska to determine the food habits for any of the slope rockfish species. Many of the abundant species, such as sharpchin, harlequin, and redstripe rockfish, are relatively small in size and may be plankton-feeders, but this is conjecture. There is also no documentation of predation on slope rockfish, although larger fishes such as Pacific halibut, which are known to prey on other rockfish, presumably also prey on slope rockfish. Because of this lack of information, the effect of FMP 1 on predator-prey relationships for slope rockfish is unknown.

Summary of Direct and Indirect Effects of FMP 1 on GOA Slope Rockfish

The effects of FMP 1 on GOA slope rockfish are summarized in Table 4.5-83. The effect of FMP 1 on these species through direct mortality from fishing is expected to be insignificant. All other potential direct and indirect effects of FMP 1 on this group are unknown.

Status Determination from Modeling

No projections are possible for the F or MSST, as slope rockfish species are classified as Tier 4 or Tier 5 fish, with insufficient information to compute either parameter.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

There is no information on the sex ratio of slope rockfish, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 1 is unknown.

Cumulative Effects of FMP 1

Table 4.5-28 summarizes the cumulative effects analysis for GOA other slope rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA other slope rockfish is rated as insignificant under FMP 1.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries and State of Alaska groundfish fisheries have been identified as having had an adverse persistent past effect on GOA other slope rockfish stocks. See Section 3.5.1.24 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause other slope rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of other slope rockfish. The State of Alaska groundfish fisheries are identified as a non-contributing factor since catch and bycatch of slope rockfish species are already accounted for by the domestic groundfish fishery management. The IPHC longline fishery is also identified as a non-contributing factor since bycatch of slope rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA other slope rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 1, the effect of changes in biomass level is unknown since the MSST for this stock is not able to be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA other slope rockfish stocks. See Section 3.5.1.24 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause other slope rockfish mortality. Climate changes and regime shifts have also been identified as having potentially beneficial or adverse effects on the other slope rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts, see Sections 3.5.1.24 and 3.10. The State of Alaska groundfish fisheries are identified as non-contributing factors to GOA slope rockfish biomass level. Although catch and bycatch do occur in these fisheries, the removals are already accounted for by the domestic groundfish fishery management. The IPHC longline fishery is also identified as a non-contributing factor since bycatch of slope rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA other slope rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal concentration of catch under FMP 1 is unknown.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA slope rockfish; however, climate changes and regime shifts have been identified as having had potentially beneficial or adverse effects on slope rockfish reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability, which in combination affect reproductive success. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to GOA slope rockfish genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic

structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure and could affect reproductive success by driving changes in prey availability and habitat suitability. The State of Alaska groundfish fishery is identified as a non-contributing factor to the change in genetic structure and reproductive success of GOA slope rockfish. Although catch and bycatch of slope rockfish species occur in these fisheries, they are not expected to contribute to localized depletion such that it leads to a detectable reduction in genetic diversity or reproductive success. The IPHC longline fishery is also identified as a non-contributing factor since bycatch of slope rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect of the spatial/temporal characteristics of the GOA slope rockfish complex is possible; however, the effect is unknown. It is unknown whether the combined effect of internal and external removals will occur in a localized manner such that it will lead to a detectable reduction in genetic diversity and reproductive success of the GOA slope rockfish complex.

Change in Prey Availability

- **Direct/Indirect Effects.** The change in prey availability under FMP 1 is unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on slope rockfish prey availability. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to slope rockfish prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potentially beneficial or adverse contributors to prey availability. See Sections 3.5.1.24 and 3.10 for more information. The State of Alaska groundfish fishery and the IPHC longline fishery are identified as non-contributing factors to slope rockfish prey availability since bycatch of slope rockfish prey species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA slope rockfish; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The change in habitat suitability is determined to be unknown under FMP 1.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries, State of Alaska groundfish fisheries, and the IPHC longline fisheries have been identified as having past persistent adverse effects on GOA slope rockfish habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA slope rockfish habitat suitability. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potentially beneficial or adverse contribution to slope rockfish habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts. The State of Alaska groundfish fishery and the IPHC longline fishery have been identified as potential adverse contributors to slope rockfish habitat suitability due to impacts from fishery gear. See Section 3.6.4 for more information on the impacts of fishery gear on EFH.

- **Cumulative Effects.** Although a cumulative effect is possible for habitat suitability of GOA slope rockfish, the effect is currently unknown due to lack of scientific information.

GOA Pelagic Shelf Rockfish – Direct/Indirect Effects of FMP 1

Until recently, dusky rockfish fell under Tier 4 of Amendment 56 of the GOA groundfish FMP, while yellowtail and widow rockfish are managed under Tier 5. As of 2004, dusky rockfish will be managed as a Tier 3 species, while the remaining pelagic shelf rockfish (PSR) species will continue under Tier 5. GOA dusky rockfish were modeled under the Tier 4 category for this analysis. The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on this group. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

The model projections for catch of PSR show a progressive decline from 3,300 mt in the baseline year of 2002 to a minimum of 2,000 mt in 2005, and only a slight increase to 2,100 mt in 2006 and 2007. These projected catches are less than would be expected if the present management regime were to remain in place, which this FMP assumes. ABC for the projections remains a constant 5,500 mt for each year, which means less than40 percent of the ABC would be taken in each of the years 2005-2007. In most years before present, at least 60 percent of the ABC for PSR has been caught. The reasons for the lower-than-expected catch projections in the model for this FMP are uncertain (Table H.4-32 for Appendix H). The impact of fishing mortality on this group is considered to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Total and Spawning Biomass

No projections are possible for these two parameters, as PSR species are classified as Tier 4 or Tier 5 fish and an age-structured model has not been finalized for dusky rockfish. Therefore, the potential impact of FMP 1 on biomass level is unknown, because biomass levels and MSSTs have not been determined.

Spatial/Temporal Concentration of Catch

The ABCs are geographically apportioned amongst the major management areas of the GOA which helps to spread out the fishery over the GOA and reduces the risk of localized depletion of the resource. However, there have been no studies to determine stock structure of dusky rockfish, and it is unknown if

subpopulations exist. Because there is no information on stock structure, there is a possibility that localized depletion may be occurring, despite the effort of geographic apportionment.

In FMP 1, there is no system for IFQs or cooperatives for rockfish trawlers, who take nearly all the catch of PSR. As a result, the PSR trawl fishery in past years has only been open for a few weeks in July. This greatly compresses the catch into a short time period and has caused a greater risk of possible overfishing, because it is difficult to manage the fishery within this short time span. The potential impact of FMP 1 is unknown, because evidence is insufficient to conclude whether the spatial and/or temporal concentration of harvest would lead to a detectable change in genetic diversity or reproductive success that would materially affect this group's ability to sustain itself at or above the MSST, and MSSTs have not been established for these stocks.

Habitat Suitability

This FMP would affect habitat for PSR because it closes the eastern GOA to trawling. This creates a *de facto* no-take zone or refugium for PSR in this area, as trawls are generally the only effective gear for capturing these species. Although biomass estimates from trawl surveys indicate that the trawl closure area in the eastern GOA only contains about 10-15 percent of the GOA biomass of dusky biomass, this is still large enough that it may provide enhanced protection to the dusky rockfish resource. Use of refugia as a conservation measure could be particularly effective for rockfish species, as most are generally believed to be sedentary in nature and not undergo extensive migrations. The closed areas may allow increased survival of larger and older fish that produce significantly more eggs and larvae to replenish the GOA population. The trawl closure also prevents damage to the benthic environment in the eastern GOA because bottom trawls cannot be used. On balance, however, evidence is insufficient to conclude whether, or to what extent, future levels of habitat protection would lead to a change in spawning or rearing success that would measurably affect the ability of the GOA slope rockfish stock to sustain itself at or above the MSST (which has not been determined for these stocks). Therefore, the potential effect of FMP 1 on habitat suitability for this group must be considered unknown.

Prey Availability

The major prey of dusky rockfish appears to be euphausiids, based on the limited food information available for this species (Yang 1993). Euphausiids are also the major prey of walleye pollock, which means dusky rockfish and walleye pollock may be competing for the same food resource. Thus, any measures in FMP 1 that affect the commercial catch of walleye pollock could have an subsequent indirect effect on dusky rockfish by increasing or decreasing the amount of euphausiids available as food to dusky rockfish. To protect Steller sea lions, FMP 1 has two measures that may reduce catch of walleye pollock: fishing closures around sea lion rookeries, and a $B_{20\%}$ fishing rule for walleye pollock. Hypothetically, these two measures could increase the abundance of walleye pollock, resulting in the consumption of more euphausiids and having an adverse effect on the food supply for dusky rockfish. How adverse this effect would really be, however, is unknown, as there is little or no quantitative information on trophic interactions between dusky rockfish and walleye pollock or data on whether they even feed on the same spatial aggregations of euphausiids.

There is no documentation of predation on dusky rockfish. Consequently, it is not possible to determine how changes in predator abundance as a result of FMP 1 would affect dusky rockfish. Presumably, larger fishes

such as Pacific halibut that are known to prey on other rockfish may also prey on adult dusky rockfish, but it unknown what impact this predation has on stock condition. Predator effects would likely be more important on juvenile dusky rockfish. Because evidence is insufficient to conclude whether future harvest levels and distribution of harvest would lead to a change in prey availability that would affect the stock's ability to sustain itself at or above the MSST, the potential effect of FMP 1 on prey availability for PSR is unknown.

Summary of Direct and Indirect Effects of FMP 1 on GOA Pelagic Shelf Rockfish

The effects of FMP 1 on GOA slope rockfish are summarized in Table 4.5-83. The effect of FMP 1 on these species through direct mortality from fishing is expected to be insignificant. All other potential direct and indirect effects of FMP 1 on this group are unknown.

Status Determination from Modeling

The catch rates are below the ABC and OFL values. The MSST cannot be determined for this stock complex.

Age and Size Composition

No projections are possible for these two parameters, as PSR species are classified as Tier 4 or Tier 5 fish and an age-structured model has not been finalized for dusky rockfish.

Sex Ratio

There is no information on the sex ratio of PSR, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 1 is unknown.

Cumulative Effects of FMP 1

Table 4.5-29 summarizes the cumulative effects analysis for GOA pelagic slope rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA PSR complex is insignificant under FMP 1.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA PSR population. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR mortality since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR mortality since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock complex to maintain current population levels is

jeopardized. Climate changes and regime shifts are not identified as being contributors to PSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA PSR and is rated as insignificant. PSR are expected to be fished at levels below the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** The effects of FMP 1 on the change in biomass level are unknown.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA demersal shelf rockfish (DSR) population. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR biomass levels since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR mortality since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to PSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for change in biomass; however, the effect is unknown since total and Bs and MSST are currently unavailable.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The effects of the fishery on the spatial/temporal characteristics of PSR under FMP 1 are unknown.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA PSR; however, climate changes and regime shifts have been identified as having had potentially beneficial or adverse effects on PSR reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination affect reproductive success. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp and fishery has been identified as a non-contributing factor to GOA PSR genetic structure and reproductive success since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate

changes and regime shifts are identified as non-contributing factors to genetic structure. However, they could affect reproductive success by driving changes in prey availability and habitat suitability.

- **Cumulative Effects.** Although a cumulative effect of the spatial/temporal characteristics of the GOA PSR complex is possible, the effect is unknown.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fishery on the change in prey availability of PSR is unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on PSR prey availability. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a potential adverse contributor to GOA PSR prey availability. The catch of shrimp in the shrimp fishery is expected to continue in the future. Marine pollution is identified as a potential adverse contributor to PSR prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potentially beneficial or adverse contributors to prey availability. See Sections 3.5.1.24 and 3.10 for more information.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA PSR; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The effect of the fishery on the change in habitat suitability of PSR is unknown.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries have been identified as having past persisting adverse effects on GOA PSR habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA PSR habitat suitability. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR habitat suitability since the gear associated with this fishery is not expected to cause a significant impact to the benthic habitat. See Sections 3.5.1.24 and 3.6 for more information on the effects of fishery gear on EFH. Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potentially beneficial or adverse contribution to DSR habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts.

- **Cumulative Effects.** Although a cumulative effect is possible for habitat suitability of GOA PSR, the effect is currently unknown due to lack of scientific information.

GOA Demersal Shelf Rockfish – Direct/Indirect Effects of FMP 1

The DSR rockfish complex comprises seven species of nearshore, bottom-dwelling rockfishes (see Section 3.5.1.24). In the eastern GOA this group of rockfishes is subject of a directed longline fishery and consequently the NPFMC manages these species separately from the other rockfish category in the eastern GOA. For purposes of this Programmatic SEIS, emphasis is placed on yelloweye rockfish as it is the predominant species in the DSR assemblage and in the fishery. DSR fall into Tier 4 of the ABC and OFL definitions. The following discussions briefly describe the direct and indirect impact analyses of FMP 1 on this group. The significance ratings for these potential effects are summarized in Appendix A, Table 4.5-83. For significance criteria, see Appendix A, Table 4.1-1.

Fishing Mortality

DSR are taken in a small directed fishery with hook and line gear and as bycatch in the halibut longline fishery. Reported catch of DSR has been relatively constant over the last five years with landings ranging from 226 mt to 363 mt in large part due to very conservative management practices. Estimated bycatch mortality of DSR in the halibut fishery has ranged about 130 mt to 355 mt annually. A DSR bycatch limit is established during the halibut season to limit mortality of DSR in this fishery. The NPFMC has also recently approved a management measure that requires full retention of DSR species. Once approved by NOAA Fisheries, the measure will improve catch statistics and reduce discards and waste. These factors, and the recognized uncertainty in estimating DSR biomass in the eastern GOA, has led managers to set a conservative TAC of 390 mt for 2003 (O'Connell *et al.* 2002). The OFL for DSR is 540 mt (Table H.4-33 for Appendix H).

Under FMP 1, we expect both the TAC and reported landings to remain stable at present levels. Status quo policies are likely to have no significant impact on the ability of DSR to sustain current population levels. Fishing mortality will remain below the OFL. The impact of fishing mortality on these stocks is considered to be insignificant under FMP 1, because it is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

Reliable total and spawning biomass statistics are not available for DSR species. Therefore, the potential impact of FMP 1 on biomass level is unknown, because biomass levels and MSSTs have not been determined.

Spatial/Temporal Concentration of Catch

Although management of this assemblage has been conservative, and overall the population appears stable, a decline in the density estimates in the Fairweather Grounds may be an indication that localized overfishing is occurring (O'Connell *et al.* 2002). The TAC for the eastern GOA is partitioned by management district based on biomass density and known habitat. The current harvest strategy indicates that two percent of the exploitable biomass is taken per year and that this level of exploitation is sustainable. However, fishing effort

on the Fairweather Grounds appears to be concentrated in areas of best habitat and highest density and it may be that local overfishing occurs. If occurring, such localized overfishing could have a long-term adverse effect on DSR stocks due to their longevity and slow growth rate (O'Connell *et al.* 2002). Rockfish stocks typically require long periods to recover from high fishing pressure. We are unable to conclusively determine the effects of the fisheries on the spatial/temporal characteristics of GOA demersal rockfish species at this time.

Habitat Suitability

Any habitat suitability impacts of FMP 1, as illustrated through the GOA groundfish FMP, would be governed by a complex web of direct and indirect interactions which are difficult to quantify. These type of impacts would include adverse effects to spawning habitat, nursery grounds, and benthic structures, as a result of commercial fishing. Unfortunately, scientific information is insufficient at the present time to conclude whether existing habitat suitability indexes would undergo any significant change under the current FMP. Therefore, the effects of FMP 1 on habitat suitability are unknown.

Prey Availability

As with habitat suitability impacts, any effects to predator-prey relationships resulting from FMP 1 management would be governed by a complex web of direct and indirect interactions which are difficult to quantify. Because evidence is insufficient to conclude whether future harvest levels and distribution of harvest would lead to a change in prey availability that would affect the stock's ability to sustain itself at or above the MSST, the potential effect of FMP 1 on prey availability for this species or group is unknown.

Summary of Effects of FMP 1 – GOA Demersal Shelf Rockfish

An age-structured population model for DSR rockfish is not used as we believe the current assessment more accurately reflects present biomass. Projections of future catch ABC and OFL levels were made by carrying forward the 2002 baseline values into the future. Under these assumptions, DSR rockfish stocks remain stable and are fished at less than the ABC in the eastern GOA, and the direct and indirect effects under FMP 1 are considered insignificant or unknown. Additional information is needed to determine whether current abundance levels are truly sustainable over the long-term, including improved time series of catch (and bycatch) by species, and age and size composition data of bycatch. Better estimates of important life history parameters and maturity schedules are also required. Improved survey techniques are needed to more accurately assess the DSR assemblage as well as more knowledge about the variety and location of complex rocky habitats in the eastern GOA.

Status Determination from Modeling

The MSST has not been determined for this stock complex.

Age and Size Composition

Age and size composition data are not available for GOA DSR species.

Sex Ratio

The sex ratio of GOA DSR species is unknown.

Cumulative Effects of FMP 1

Table 4.5-30 summarizes the cumulative effects analysis for GOA demersal slope rockfish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA DSR complex is insignificant under FMP 1.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and the IPHC longline fishery have been identified as non-contributing factors to GOA DSR mortality since catch and bycatch in these fisheries are already accounted for by the domestic fishery management levels or bycatch is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA DSR mortality since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to DSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA DSR and is rated as insignificant. DSR are expected to be fished at levels below the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** The effect of the fishery on the change in biomass under FMP 1 is unknown.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and the IPHC longline fishery have been identified as non-contributing factors to GOA DSR biomass levels since catch and bycatch in these fisheries are already accounted for by the domestic fishery management levels or bycatch is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA DSR mortality since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the capacity of the

stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to DSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for change in biomass; however, the effect is unknown since total and Bs are currently unavailable.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The effect of the fisheries on the spatial/temporal characteristics of GOA DSR is unknown.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA DSR; however, climate changes and regime shifts have been identified as having had potentially beneficial or adverse effects on DSR reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and IPHC longline fisheries have been identified as non-contributing factors to GOA DSR genetic structure and reproductive success. Catch and bycatch of these fisheries are already accounted for by the domestic groundfish management or bycatch is not expected to occur (as in the case of the State of Alaska herring and shrimp fisheries). Marine pollution is identified as a potential adverse contributor to GOA DSR genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure. However, they could affect reproductive success by driving changes in prey availability and habitat suitability.

- **Cumulative Effects.** Although a cumulative effect on the spatial/temporal characteristics of the GOA DSR complex is possible, the effect is unknown.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in prey availability under FMP 1 is unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on DSR prey availability. See Sections 3.5.1.24 and 3.10 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring and shrimp fisheries have been identified as potential adverse contributors to GOA DSR prey availability. Catch of herring in the herring fishery and the catch of shrimp in the shrimp fishery are expected to continue

in the future. The State of Alaska groundfish fishery and the IPHC longline fishery are identified as non-contributing factors to GOA DSR prey availability since bycatch of DSR prey species in not expected to occur. Marine pollution is identified as a potential adverse contributor to DSR prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potentially beneficial or adverse contributors to prey availability. See Sections 3.5.1.24 and 3.10 for more information.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA DSR; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Scientific information is insufficient at the present time to conclude whether existing habitat suitability indexes would undergo any significant change under the current FMP.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries and the IPHC longline fisheries have been identified as having past persisting adverse effects on GOA DSR habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA DSR habitat suitability. See Section 3.5.1.24 for more information.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring and shrimp fisheries have been identified as non-contributing factors to GOA DSR habitat suitability since the gear associated with these fisheries are not expected to cause a significant impact to the benthic habitat. The State of Alaska groundfish fisheries and the IPHC longline fisheries are identified as potential adverse contributors to DSR habitat suitability. See Sections 3.5.1.24 and 3.6 for more information on the effects of fishery gear on EFH. Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potentially beneficial or adverse contribution to DSR habitat suitability. See Sections 3.5.1.24 and 3.10 for more information on climate changes and regime shifts.

- **Cumulative Effects.** Although a cumulative effect is possible for habitat suitability of GOA DSR, the effect is currently unknown due to lack of scientific information.

4.5.2 Prohibited Species Alternative 1 Analysis

Throughout these analyses, the prohibited species category is discussed separately from the non-target groundfish species groups since their management strategies are implemented by various agencies outside of NOAA Fisheries. Retention of prohibited species is forbidden in the BSAI and GOA groundfish fisheries. The prohibited species include:

- Pacific halibut (*Hippoglossus stenolepis*).

- Pacific salmon and steelhead trout (*Oncorhynchus mykiss*).

- Pacific herring (*Clupea pallasi*).

- Red king crab (*Paralithodes camtschaticus*), blue king crab (*P. Platypus*), golden or brown king crab (*Lithodes aequispinus*), bairdi Tanner crabs (*Chionoecetes bairdi*), and opilio Tanner crabs *(C. opilio*).

4.5.2.1 Pacific Halibut

Pacific halibut are managed by the IPHC. Halibut bycatch in federal groundfish fisheries is controlled by the use of PSC limits. IPHC provides for all removals of halibut, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, changes in bycatch (increase or decrease) are reflected in changes to quotas set for the directed fishery.

Under the present groundfish FMPs, halibut bycatch mortality in the Alaska groundfish fisheries is limited by NOAA Fisheries to approximately 4,500 mt in the BSAI and 2,300 mt in the GOA, for a total of 6,800 mt. Total removals from both areas in 2002 were limited by IPHC to a conservative target of 48,800 mt (Clark and Hare 2003). This was achieved by limiting the directed commercial fishery to a catch of 37,100 mt, which allowed for the expected total of 11,700 mt in sport catch, bycatch, and subsistence.

Direct/Indirect Effects

Direct and indirect effects for Pacific halibut include mortality along with changes in reproductive success and prey availability. These effects, which are associated with changes in catch and bycatch, are considered insignificant because annual quota setting processes implemented by IPHC account for all removals of halibut including bycatch in other fisheries. Thus, if changes to the baseline condition of the stock occur, they are reflected in the quotas set for the directed fishery. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. Halibut are opportunistic predators with a wide range of prey species and no significant change to prey structure is expected as a result of FMP 1. No evidence of fishery impacts to habitat of halibut has been shown, so this effect will not be considered in the cumulative effects analysis that follows.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 1 is shown in Table 4.5-31. For further information on persistent past effects included in this analysis, see Section 3.5.2.1 of this SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA Pacific halibut is insignificant under FMP 1 because current management of halibut by IPHC accounts for all removals of halibut including bycatch in other fisheries when setting quotas for the directed fishery. Thus, if changes to the baseline condition of the stock occur, quotas set by the IPHC for the directed fishery will be adjusted accordingly.

- **Persistent Past Effects.** No persistent past effects of mortality on Pacific halibut have been identified. It is inferred that halibut bycatch in the past fisheries was accounted for under the IPHC management process that is still in effect today.

- **Reasonably Foreseeable Future External Effects.** The directed longline fishery for Pacific halibut remains in effect but is closely managed by IPHC. Although state-managed fisheries may incidentally catch halibut, IPHC provides for all removals, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, changes in halibut bycatch (increase or decrease) are reflected in changes to quotas set for the directed fishery. The directed longline fishery and other state-managed fisheries are not considered to be contributing factors to changes in halibut mortality. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** The combined effects of mortality on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effect of changes in reproductive success on BSAI and GOA Pacific halibut is insignificant under FMP 1. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. No significant change from the baseline condition is expected as a result of FMP 1.

- **Persistent Past Effects.** No persistent past effects have been identified on changes in reproductive success of Pacific halibut. Currently, halibut stocks are considered healthy and stable.

- **Reasonably Foreseeable Future External Effects.** Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in reproductive success for halibut since there is no significant spatial/temporal overlap between these fisheries and halibut spawning areas. Long-term climate change and regime shifts could have impacts on the reproductive success of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in reproductive success on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 1.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effect of changes in prey availability on BSAI and GOA Pacific halibut is insignificant under FMP 1. Halibut are opportunistic predators with a wide range of prey species and no significant change to prey structure is expected as a result of FMP 1.

- **Persistent Past Effects.** No persistent past effects impacting prey availability of halibut have been identified.

- **Reasonably Foreseeable Future External Effects.** Halibut are opportunistic predators with a wide range of prey species. Increase in prey competition between Pacific halibut and fisheries catch is not expected. Thus, the directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in prey availability for halibut. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on the prey structure of halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in prey availability on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 1.

4.5.2.2 Pacific Salmon or Steelhead Trout

Pacific salmon are managed by the ADF&G, which also manages the salmon sport fisheries and permitted subsistence harvesting, to ensure that escapement goals are met for the spawning population in order to maintain sustained yields from the stock as a whole. Annual harvest levels are responsive to fluctuations in run sizes.

Most Alaska salmon fisheries are stable with bycatch representing a very small proportion of the directed fisheries catch. Pollock fisheries account for approximately 90 percent of the salmon bycatch in the BSAI. However, the western Alaska chinook and chum salmon stocks are currently considered depressed. Stock composition of BSAI groundfish fisheries bycatch shows that approximately 58-70 percent of chinook bycatch and 19 percent of chum bycatch may originate in western Alaska stocks. Many western Alaska rivers from Bristol Bay to Kotzebue are major producers of chinook or chum salmon. Although these species occur in a large number of drainages throughout the region, the largest runs exist in the Nushagak, Kuskokwim, and Yukon Rivers. Throughout the region these species are subject to intense subsistence and commercial fisheries. These runs have been poor since 1998 when the Arctic-Yukon-Kuskokwim (AYK) region was declared an economic disaster area. In 2001, the Alaska Board of Fisheries designated many AYK chinook and chum salmon stocks as Stocks of Concern under the State of Alaska's Policy for the Management of Sustainable Salmon Fisheries. Among the stocks designated were Kuskokwim River chinook and chum salmon, Yukon River chinook and chum salmon, and Norton Sound chum salmon.

Annual commercial and subsistence harvest of chinook and chum salmon for Bristol Bay and AYK combined averaged approximately 300,000 chinook salmon and 1,100,000 chum salmon from 1998 through 2000 (Burkey *et al.* 2001, Vania *et al.* 2002, Weiland *et al.* 2001, Brennan *et al.* 2002). Year 2000 was particularly poor for both chinook and chum salmon throughout the region. Total chinook catch for the region was approximately 190,000 fish, down from almost 400,000 fish in 1998. Total chum salmon catch for the region was approximately 640,000 fish, down from about one million in the previous two years, which were considered depressed as well. These poor runs resulted in extensive commercial closures for chinook and chum and subsistence closures for chum salmon in the AYK region since 1998.

Of the Northwest salmon species listed as endangered or threatened under the ESA, chinook and steelhead stocks are thought to migrate into areas managed by BSAI and GOA groundfish FMPs. Steelhead trout have not been observed in BSAI or GOA groundfish fisheries salmon bycatch. Bycatch of chinook salmon originating in the Northwest may occur in groundfish fisheries; however, ADF&G intensely manages this stock to ensure that bycatch does not exceed limits set forth by the ESA. Thus, ESA-listed Pacific Northwest chinook salmon and steelhead trout were not specifically considered in this cumulative effects analysis.

Of the 407 chinook stocks harvested in the regioneast, 81 percent are classified as not threatened, and 15 percent are special concern or at risk (Slaney *et al.* 1996). Large portions of the regioneast chinook harvest originate from the Columbia River upriver bright chinook, Middle Columbia River bright chinook, and north-migrating Oregon coastal chinook; these stocks are considered stable (NMFS 2002). Chinook stocks listed under the ESA make up a small portion of the regioneast harvest, and nearly all coho salmon harvested originate from Alaskan streams (Weitkamp *et al.* 1995).

Management of Alaskan salmon stocks is challenging due to the lack of precise information on total return and the inability to predict future returns to most rivers or tributaries with any degree of certainty. In most cases, total return and escapement are not known. As a result of this lack of information, estimates of significant impacts of bycatch on various runs are unreliable. Another factor to consider in salmon management is the Alaska subsistence preference law cite. This law requires that commercial, recreational, and personal use fisheries be restricted before restriction of subsistence fisheries. Therefore, management of all fisheries for these stocks in state waters incorporates conservative measures.

For analysis of the impacts of the FMPs presented here, the following assumptions have been made:

- 96 percent of "other salmon" caught in the BSAI are chum salmon (taken from observer data 1997-1999).

- BSAI chinook and other salmon bycatch is comprised of 58 to 70 percent of western Alaska chinook, and 19 percent of western Alaska chum salmon. Western runs occur in Bristol Bay, Kuskokwim, Nushagak, Yukon, Norton Sound, and Kotzebue regions. Runs in this region are considered depressed, due to severely poor runs in the Yukon and Kuskokwim River drainages in recent years.

- GOA chinook and other salmon bycatch is comprised of approximately 58 percent of western Alaska chinook and an unknown percentage of western Alaska chum salmon. Other GOA salmon bycatch originates from southeast Alaska and British Columbia runs. Spawning escapement of chinook and other salmon in southeast Alaska are stable and increasing in many of the management units.

The cumulative effects analysis was based on two groupings of Alaska salmon in BSAI and GOA: chinook salmon and other salmon. As stated in the assumptions above, 96 percent of other salmon caught in BSAI is considered to be chum salmon.

Direct/Indirect Effects

Direct and indirect effects to chinook salmon and other salmon in BSAI and GOA include mortality, changes to prey availability, genetic structure of population, and reproductive success.

BSAI – Chinook Salmon

Under FMP 1, chinook salmon bycatch in the BSAI varies from approximately 26,000 in 2003 down to 23,000 in 2008. Assuming 58 to 70 percent of BSAI chinook salmon bycatch may be of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 13,000 to 18,000 fish during the next six years. This harvest represents approximately 4.3 to 6.0 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. The effects of this level of bycatch are not detectable in natal streams and would have little or no effect on commercial or subsistence harvests or escapement. It is unlikely that this level of bycatch, when considered across all chinook salmon runs in western Alaska, would impact the sustainability of the stock and is therefore considered insignificant under FMP 1. However, given the current poor stock status of chinook salmon runs in western Alaska and considering the combined bycatch potential in BSAI and GOA, bycatch levels significantly higher from those predicted for FMP 1 could adversely impact recovery of depressed stocks.

BSAI – Other Salmon

Under FMP 1, bycatch of other salmon in BSAI varies from approximately 69,000 in 2003 down to 58,000 in 2008. Assuming 96 percent of other salmon bycatch is chum salmon and 19 percent may be of western Alaska origin, the bycatch of western Alaska chum salmon stocks could range from 11,000 to 13,000 fish during the next six years. This harvest represents approximately 1.0 to 1.2 percent of the average western Alaska commercial and subsistence harvest of approximately 1,100,000 chum salmon from 1998 through 2000. The effects of this level of bycatch are not detectable in natal streams and would have little or no effect on commercial or subsistence harvests or escapement. It is unlikely that this level of bycatch, when considered across all chum salmon runs in western Alaska, would impact the sustainability of the stock and is therefore considered insignificant under FMP 1. However, given the current poor stock status of chum salmon runs in western Alaska, harvest level higher than those predicted under FMP 1 could adversely impact recovery of depressed stocks.

GOA – Chinook Salmon

Under FMP 1, chinook salmon bycatch in the GOA varies from approximately 13,000 in 2003 up to 28,000 in 2008. Assuming 58 percent of GOA chinook salmon bycatch may be of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 8,000 to 16,000 fish during the next six years. This harvest level represents approximately 2.6 to 5.3 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. The effects of this level of harvest are not detectable in natal streams and would have little or no effect on commercial or subsistence harvests and escapement. It is unlikely that this level of bycatch, when considered across all chinook salmon runs in western Alaska, would impact the sustainability of the stock and is therefore considered insignificant under FMP 1. Population-level effects of bycatch on depressed stocks are difficult to determine. However, given the poor stock status of chinook salmon runs in western Alaska and considering the combined bycatch potential in BSAI and GOA fisheries, bycatch levels significantly higher than those predicted for FMP 1 could adversely impact recovery of depressed stocks.

GOA – Other Salmon

Under FMP 1, bycatch of other salmon in GOA varies from approximately 5,000 in 2003 up to 11,000 in 2008. Assuming 56 percent of other salmon bycatch is chum salmon, the bycatch could range from 3,000 to 6,000 fish during the next six years. The proportion of these fish originating in western Alaska is unknown. Assuming that 100 percent of these fish were of western Alaska origin, this harvest represents approximately 0.3 to 0.5 percent of the average western Alaska commercial and subsistence harvest of approximately 1,100,000 chum salmon from 1998 through 2000. This level of bycatch is not detectable in natal streams and would have little or no effect on commercial or subsistence harvests and escapement. It is unlikely that this level of bycatch, when considered across all chum salmon runs in western Alaska, would impact the sustainability of the stock and is therefore considered insignificant under FMP 1.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 1 is shown in Tables 4.5-32 and 4.5-33. For further information on persistent past effects included in this analysis, see Section 3.5.2.2 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA chinook and other salmon is considered insignificant for FMP 1. The predicted level of bycatch would not be detectable in natal streams and would have little or no effect on commercial or subsistence harvests or escapement. It is unlikely that this level of bycatch, when considered across all salmon runs in western Alaska, would impact the sustainability of the stock. However, if currently depressed stocks continue to decline in the future, then possible adverse effects of mortality could exist for BSAI and GOA chinook and BSAI other salmon. The likelihood of these potential trends in salmon stocks throughout Alaska cannot be determined at this time.

- **Persistent Past Effects.** Past foreign fisheries in Japan and Russia are associated with direct catch and bycatch of salmon in BSAI and GOA. U.S. bilateral agreements with these countries attempted to reduce gear conflicts between State of Alaska salmon fisheries and foreign fisheries while allocating salmon resources to the state fisheries. These bilateral agreements were considered marginal management measures for protection of salmon stocks. Before 1959, salmon fisheries in Alaska were managed federally. The state took over salmon management after statehood in 1959. However, the domestic fleet continued to grow during the years to follow, and by the 1970s the state initiated a limited entry system upon the realization that salmon stocks were being overfished. Persistent past effects of mortality on Alaskan salmon stocks exist and are associated with past foreign, JV, and domestic groundfish fisheries.

- **Reasonably Foreseeable Future External Effects.** State commercial and subsistence fisheries exert effects on mortality of BSAI and GOA chinook and other salmon populations. The magnitude of this effect cannot be determined; however, current stock status of salmon runs in western Alaska are depressed. These fisheries are not considered contributing factors in mortality of other non-western chinook or other salmon populations. In considering this stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential

adverse contribution to the population as a whole. Land management practices heavily influence the condition of watersheds used by spawning salmon but are not considered contributing factors in direct mortality of salmon. State hatchery enhancement programs were initiated in GOA and have a potential beneficial contribution to effects of mortality on salmon stocks. In addition, long-term climate change and regime shift are not expected to result in direct mortality of salmon.

- **Cumulative Effects.** Given the poor stock status of salmon runs in western Alaska, the combined effects of mortality on BSAI and GOA chinook and BSAI other salmon resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered conditionally significant adverse for FMP 1. Combined bycatch potential in the BSAI and GOA fisheries under this FMP could impact the successful recovery of depressed stocks in the BSAI and GOA and sustainability of the stocks as a whole. Current stock status GOA other salmon is considered stable, and combined effects of mortality on other salmon in this region resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effects of FMP 1 on prey availability for BSAI and GOA chinook and other salmon are unknown. A relationship between fisheries bycatch of salmon prey items and salmon prey availability has not been defined.

- **Persistent Past Effects.** It has not been determined if past effects are currently impacting prey availability for BSAI and GOA chinook and other salmon.

- **Reasonably Foreseeable Future External Effects.** In both the BSAI and GOA, a relationship between state commercial, subsistence, and (in the GOA) sport fisheries bycatch of prey and salmon prey availability has not been defined and potential effects are unknown. Land management practices are not considered contributing factors in prey availability of salmon as it is not likely that they would impact the marine environment in which salmon forage. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific salmon in the BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on the prey structure of salmon cannot be determined at this time. State hatchery enhancement programs exist in the GOA but do not include prey species of salmon.

- **Cumulative Effects.** The combined effects of potential changes in prey availability for BSAI and GOA chinook and other salmon resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are unknown under FMP 1.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of FMP 1 on genetic structure of salmon populations in BSAI and GOA are unknown.

- **Persistent Past Effects.** It has not been determined if past effects may be impacting the genetic structure of the BSAI and GOA chinook and other salmon populations.

- **Reasonably Foreseeable Future External Effects.** In both the BSAI and GOA, salmon bycatch composition has not been determined. Potential effects of state commercial and subsistence fisheries, along with sport fisheries in the GOA, on genetic structure of salmon populations are unknown. Significant impacts to genetic structure of salmon populations by land management practices are not expected and are not considered contributing factors to a possible change in baseline condition. Long-term climate change and regime shifts are not expected to result in direct mortality that would potentially affect genetic structure of the BSAI and GOA chinook and other salmon stocks. In the GOA, state hatchery enhancement programs focus on building certain salmon stocks, but because actual stock composition for all species of salmon is unknown, the potential effects of this program on genetic structure of salmon populations in GOA are not known.

- **Cumulative Effects.** Due to the uncertainty of current stock composition for chinook and other salmon in BSAI and GOA, the combined effects of changes in genetic structure on salmon populations in Alaska resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are unknown under FMP 1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of FMP 1 on reproductive success for BSAI and GOA chinook and other salmon are unknown.

- **Persistent Past Effects.** Given the poor stock status of salmon runs in western Alaska it may be inferred that reproductive success has been impacted in certain salmon populations originating in the BSAI region. Successful reproduction of salmon depends on spawning adults' ability to reach destined spawning habitat. Persistent past effects of mortality on salmon stocks exist and it is likely that reproductive success of these stocks has suffered as a result. Other past effects tied to freshwater life stages of salmon may also play a role in the reproductive success of certain salmon populations. Non-western Alaska salmon stocks in GOA are currently considered stable so it is inferred that any past effects on the population have been mitigated over time.

- **Reasonably Foreseeable Future External Effects.** State commercial and subsistence fisheries catch of western Alaska chinook and other salmon populations could cause potential adverse impacts to reproductive success of these already depressed stocks. Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. The direct take of these fish would prevent their return to spawning grounds. In considering this depressed stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. Degradation of watersheds used by spawning salmon resulting from poor land management practices, could significantly impact the reproductive success of BSAI and GOA chinook and BSAI other salmon stocks. Thus, these practices are considered potential adverse contributions to changes in reproductive success of these populations.

Other salmon stocks in GOA are considered stable; so potential effects of state commercial, subsistence, and sport fisheries on reproductive success of these stocks are considered insignificant. For reasons stated above, land management practices are considered potential adverse contributors to the reproductive success of GOA salmon stocks. Hatchery enhancement programs in the GOA may help to restore depressed stocks and maintain stable stocks in Alaska and are considered potentially beneficial to populations of chinook and other salmon.

Long-term climate change and regime shifts could have impacts on the reproductive success of Pacific salmon in BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on reproductive success of BSAI and GOA salmon cannot be determined at this time.

- **Cumulative Effects.** Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. Given the poor stock status of salmon runs in western Alaska and combined bycatch potential in the BSAI and GOA fisheries, the sustainability of BSAI and GOA chinook and BSAI other salmon stocks could be impacted. However, it is unknown whether these potential changes to stock status would be driven by changes in reproductive success, specifically, as a result of persisting past effects and reasonably foreseeable future external effects (human controlled and natural events). Current stock status of GOA other salmon is stable, but combined effects of changes in reproductive success in Alaskan salmon populations resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) cannot be determined at this time for GOA other salmon stocks under FMP 1.

4.5.2.3 Pacific Herring

Pacific herring are managed by the ADF&G. Harvest policy and allocations among gear (user) groups are established by the Alaska Board of Fisheries. Annual harvest quotas are set by ADF&G under an exploitation rate harvest policy; herring exploitation rates are capped at a maximum level of 20 percent statewide. All directed herring fisheries occur in state waters and are managed by regulatory stocks.

Direct/Indirect Effects

Direct and indirect effects for Pacific herring include mortality along with changes in reproductive success, prey availability, and habitat. These effects, which are associated with changes in catch, are considered insignificant for the following reasons: bycatch of herring in the groundfish fisheries is low, the fisheries do not target herring prey, and spatial/temporal overlap between the groundfish fisheries and herring habitat is minimal. In addition, annual quota setting processes implemented by ADF&G are responsive to fluctuations in herring biomass.

Under all FMPs, Pacific herring bycatch in groundfish fisheries is considerably lower than some of the highest catch years recorded following passage of Amendment 16A in 1991. Only under the relatively unrestricted fishing of FMP 2.1 does herring bycatch even begin to approach the levels of herring bycatch in the early 1990s.

However, it is somewhat disturbing that even with the relatively unrestricted fishing, the model's estimates of herring bycatch are less than those actually observed in 1990-92. Herring stock levels are thought to be approximately similar to those in the early 1990s. The lower herring bycatch portrayed by the model likely results from the use of highly aggregated and temporally-averaged bycatch rates. In the early 1990s, fishing vessels likely encountered dense concentrations of herring schools by chance. Temporally and spatially averaged bycatch rates will not simulate these occasional encounters, but will still represent an average herring bycatch long-term.

While these are the best data available for this modeling approach, they do represent averages over time and space. For a species with dense spatial aggregations that move dynamically through time, this may not be the best prediction of specific future scenarios. These scenarios assume that future distributions of fishing effort in space and time will be similar to those in the past. Given the available data, it is the best that can be done.

Population dynamics of Pacific herring are not explicitly modeled. Therefore the effects of the management measures on herring biomass are not evaluated. However, given the low herring bycatch levels under all of the scenarios, bycatch removals would not be expected to have a detectably different impact on herring abundance estimates.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 1 is shown in Table 4.5-34. For further information on persistent past effects included in this analysis, see Section 3.5.2.3 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA herring is insignificant under FMP 1 given the low amounts predicted for herring bycatch, and because current management of herring by ADF&G is responsive to fluctuations in herring biomass. The herring savings areas reduce herring bycatch potential by triggering closures in years when herring are abundant within fishing grounds.

- **Persistent Past Effects.** Domestic herring fisheries became prominent in the early 1900s with peak catches occurring in the 1920s and 1930s. Foreign herring harvests became prominent in the BSAI in the late 1950s, with highs in the late 1960s and early 1970s. Overexploitation of herring likely resulted during these years of high catch rates. By 1980, foreign harvest of herring had been eliminated; however, years of unregulated catch of herring may have impacted herring populations long-term. In addition, past federal groundfish fisheries bycatch combined with the directed state fisheries have exceeded the state's herring harvest policy in the past and may still exert lingering effects on current herring populations in the BSAI and GOA.

- **Reasonably Foreseeable Future External Effects.** Directed state herring fisheries still occur but are closely managed by the state (ADF&G). Fishing quotas are based on variable exploitation rates that account for declines in stock and are capped at a maximum rate of 20 percent. State subsistence catch is also accounted for in ADF&G herring management plans. These fisheries are not considered

contributing factors to changes in herring mortality. Future acute and chronic marine pollution could occur and is considered potentially adverse to herring mortality, especially for those populations that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** ADF&G's Pacific herring management plans are responsive to changes in herring biomass and fishing quotas are based on variable exploitation rates that account for declines in stock and are capped at a maximum rate of 20 percent. Thus, although some persistent past effects may still be present on certain herring populations in the BSAI and GOA, the combined effects of mortality on Pacific herring resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on reproductive success of BSAI and GOA herring is insignificant under FMP 1, due to the low amounts of estimated herring bycatch and because current management of herring by ADF&G is responsive to fluctuations in herring biomass. Thus, if a change in reproductive success occurs, it would most likely be reflected in corresponding changes to biomass, which are incorporated into ADF&G management plans for Pacific herring.

- **Persistent Past Effects.** Domestic herring fisheries became prominent in the early 1900s with peak catches occurring in the 1920s and 1930s. Foreign herring harvests became prominent in the BSAI in the late 1950s, with highs in the late 1960s and early 1970s. Overexploitation of herring likely resulted during these years of high catch. By 1980, foreign harvest of herring had been eliminated; however, years of unregulated catch of herring may have had long-term impacts on herring populations. In addition, past federal groundfish fisheries bycatch combined with the directed state fisheries have exceeded the state's herring harvest policy in the past and may still exert lingering effects on current herring populations in the BSAI and GOA. Herring spawning habitat in the GOA (specifically PWS) was contaminated with oil resulting from the EVOS in 1989. It has been found that this type of contamination exposure to adult and larval herring can result in many adverse effects such as: increased rates of egg mortality, larval deformities, and immune system deficiencies. It is presumed that the effects of EVOS still exist and subsets of herring populations in the GOA are still recovering.

- **Reasonably Foreseeable Future External Effects.** Directed state herring fisheries still occur but are closely managed by the state (ADF&G). Fishing quotas are based on variable exploitation rates that account for declines in stock. State subsistence and other state groundfish fisheries catch are also accounted for in ADF&G herring management plans. Thus, these fisheries are not considered contributing factors to changes in herring reproductive success. Future acute and chronic marine pollution could occur and is considered potentially adverse to herring reproductive success, especially for those populations that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts could have impacts to the reproductive success of Pacific herring depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on herring cannot be determined at this time.

- **Cumulative Effects.** ADF&G Pacific herring management plans are responsive to changes in herring biomass and fishing quotas are based on variable exploitation rates that account for declines in stock. Although certain herring populations in the GOA have been impacted by EVOS, the stock as a whole is considered recovering. Thus, some persistent past effects may still be present on certain herring populations in the BSAI and GOA, but the combined effects on Pacific herring reproductive success resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 1.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on prey availability for BSAI and GOA herring is insignificant under FMP 1 because groundfish fisheries do not target herring prey and current management by ADF&G is responsive to fluctuations in herring biomass regardless of the cause associated with the change. Thus, if a change in prey availability did occur, it would most likely be reflected in corresponding changes to biomass, which are accounted for in ADF&G management plans of Pacific herring.

- **Persistent Past Effects.** No persistent past effects impacting prey availability of herring have been identified.

- **Reasonably Foreseeable Future External Effects.** Pacific herring prey primarily on zooplankton which are not a component of bycatch from state directed herring fisheries, state commercial fisheries, or state subsistence fisheries. Thus, these fisheries are not considered contributing factors to changes in prey availability for herring. Future acute and chronic marine pollution could occur but effects on prey, such as zooplankton, are unknown. Long-term climate change and regime shifts could have impacts to many species that contribute to the prey structure of Pacific herring. The nature of these impacts depends on the direction of the climatic shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on herring cannot be determined at this time.

- **Cumulative Effects.** Potential effects of future natural events, such as marine pollution and climatic shifts, on prey availability for Pacific herring are unknown.

Change in Habitat

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on habitat of BSAI and GOA herring is insignificant under FMP 1, because current management of herring by ADF&G is responsive to fluctuations in herring biomass and spatial/temporal overlap between the fisheries and herring habitat is minimal. However, if the groundfish fisheries were to somehow impact herring habitat, it would most likely be reflected in corresponding changes to biomass, which are accounted for in ADF&G management plans of Pacific herring. In addition, the herring savings areas reduce herring bycatch potential and protect important habitat by triggering closures in years when herring are abundant within fishing grounds.

- **Persistent Past Effects.** Herring spawning habitat in the GOA (specifically PWS) was contaminated with oil resulting from the EVOS in 1989. The long-term effects of this event to herring habitat are

unknown. It is presumed that the effects of EVOS still exist and subsets of herring populations in the GOA are still recovering.

- **Reasonably Foreseeable Future External Effects.** No evidence of fishery impact on habitat of herring exists. Thus, fisheries are not considered contributing factors to changes in herring habitat at this time. Future acute and chronic marine pollution could occur and is considered potentially adverse to some herring habitat, especially those that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts are not expected to significantly change physical habitat of Pacific herring.

- **Cumulative Effects.** Potential impacts of future natural events, such as marine pollution and climatic shifts, in addition to lingering contamination from EVOS on certain habitat of herring in the GOA exist but effects are not known.

4.5.2.4 Crab

Alaska king, bairdi Tanner crab, and opilio Tanner crab (also called snow crab) fisheries are managed by the State of Alaska with federal oversight and following guidelines established in the BSAI king and Tanner crab FMP (NPFMC 1989). King, bairdi, and opilio Tanner crab are prohibited species for the state scallop and groundfish fisheries and Federal groundfish fisheries. This means that any crab bycatch must be discarded. Crab regulations focus on concerns about direct impacts to crab populations by trawling, considered trawl-induced mortality, and indirect impacts through habitat degradation as well. Because bycatch mortality is currently considered to be minor relative to other sources of mortality for crab, temporal and spatial closures are thought to be more effective than PSC limits in reducing impacts of trawling on crab stocks (Witherell and Harrington 1996). As such, numerous trawl closure areas have been instituted to address concerns about unobserved mortality (crab wounded or killed but not captured), and possible habitat degradation due to trawling and dredging.

With the exception of Norton Sound, Bristol Bay, and potentially the Pribilof Islands, all major western red king crab stocks are depressed and their associated fisheries are closed (ADF&G 2000). St. Matthew Island blue king crab was declared overfished in 1999 and the fishery closed. A rebuilding plan has been implemented. Red and blue king crab fisheries in the Pribilof Islands are closed and stocks considered either overfished or in decline. A rebuilding plan for the Pribilof Islands blue king crab stock is currently being developed. Golden king crab stock status in the BSAI and GOA is unknown due to lack of survey information. Bering Sea Tanner crab fisheries were closed in 1997 and stocks were declared overfished. A rebuilding plan is currently in effect for these stocks. Opilio Tanner crab populations in the BSAI are in decline and have been declared overfished. Overall status of bairdi Tanner and red king crab species in the GOA reflects population declines. However, blue and golden king crab are not actively assessed in the GOA at this time.

For the cumulative effects analysis, crab stocks in the BSAI and GOA will be placed in the following groups: bairdi Tanner, opilio Tanner (only BSAI), red king, blue king, and golden king.

Direct/Indirect Effects

Direct and indirect effects for all species of crab in the BSAI and GOA include mortality along with changes in biomass, reproductive success, prey availability, and habitat. These effects may be attributed to fishing activities (both directed and undirected), but may also be linked to natural events such as long-term climatic change and decadal regime shifts. Significance of these effects is based on the likelihood that population-level changes will result from internal events within the groundfish fishery. An effect that is considered insignificant corresponds to a change that is not likely to result in population-level effects on crab or that lies within the range of natural variability for the species.

Cumulative Effects Analysis

Summaries of the cumulative effects analyses associated with FMP 1 are shown in Tables 4.5-35 through 4.5-42 . For further information on persistent past effects included in this analysis, see Section 3.5.2.4 of this Programmatic SEIS.

The foundation of the cumulative effects analysis is the baseline description for each species that includes population status and trends, if known, and the major human and natural influences that have affected the population in the past and that continue up to the present.

For each species, the predicted direct and indirect effects of the groundfish fishery are then analyzed for their contribution to the overall impacts from all sources, including reasonably foreseeable future events resulting from human and natural events external to the fishery. The reasonably foreseeable future events also include other U.S. and foreign fisheries, acute and chronic environmental pollution, and natural events such as climatic and oceanographic fluctuations. Cumulative effects are each rated according to the same significance criteria as the direct/indirect effects of the fishery and are based on the potential for population-level effects.

Mortality

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Under FMP 1, predicted catch of these crab species does not significantly change from the current baseline condition although catch trends do increase and decrease throughout the five-year period. Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. The level of crab bycatch predicted for 2003 through 2007 would not be expected to further impede the recovery of these already depressed stocks. Thus, the effects of FMP 1 on mortality of bairdi Tanner, opilio Tanner, red king, and blue king crab are considered insignificant, due to the lack of significant recovery of these stocks while protective measures have been in place.

- **Persistent Past Effects.** Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s but was eliminated in 1976 with the implementation of the MSA. This area

coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey in review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur, and although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. Thus, these fisheries are considered to have potential adverse effects on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI since no signs of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock also has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed but is not in effect at the time of this writing. Rebuilding plans may have beneficial effects on recovery of these stocks as a whole, over time. BSAI red king crab stocks do not have rebuilding plans in effect but the populations are currently considered depressed. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in mortality.

- **Cumulative Effects.** ADF&G's crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on crab populations in the BSAI may still exist and stocks are considered depressed with no signs of recovery to date. Thus, these combined effects of mortality, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events, are considered conditionally significant adverse for FMP 1. These effects could further impede the recovery of the population, although the driving factor(s) behind the BSAI crab stocks' lack of recovery have not been determined.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Under FMP 1, predicted catch rates of golden king crab in BSAI and GOA were combined with those for blue king crab. The BSAI predictions showed increases and decreases in catch over the next five years when compared to current catch rates. Model projections for GOA catch showed decreases in catch compared to current catch in this region. However, the significance of these predicted changes in catch on mortality is unknown due to lack of survey information for determining current stock status. Thus, effects of FMP 1 on mortality of BSAI and GOA golden king crab are unknown.

- **Persistent Past Effects.** Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in the BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab in the BSAI during this time increased proportionally with the direct catch of these fisheries. However, this is only applicable for the BSAI

because BSAI fisheries would not influence GOA stocks. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures, providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in BSAI and GOA is currently unknown. Thus, the potential effects of crab bycatch in other fisheries are not known. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G's crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on golden king crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed but the overall stock status of golden king crab in BSAI and GOA is unknown. Thus, potential combined effects of mortality, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 1.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Under FMP 1, predicted catch of bairdi Tanner, red king, and blue king crab in GOA showed decreases from the current catch levels over the next five years. However, significance of these predicted changes in catch on mortality is unknown for blue king and bairdi Tanner crab due to lack of survey information for determining current stock status. Thus, the effects of FMP 1 on mortality of GOA blue king and bairdi Tanner crab are unknown. GOA red king crab surveys indicate the stock is depressed, with no signs of rebuilding. The level of red king crab bycatch predicted for 2003 through 2007 (63% lower than baseline conditions) would not be expected to further impede the recovery of the stock. Thus, the effects of FMP 1 on mortality of red king crab stocks are considered insignificant, due to the lack of recovery of these stocks while protective measures have been in place.

- **Persistent Past Effects.** Crab bycatch is common in bottom trawl fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of external fisheries on mortality of bairdi Tanner and blue king crab stocks are not known. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in addition to external mortality associated with state fisheries (directed, subsistence, and scallop), could adversely impact recovery and sustainability of red king crab stocks in the GOA. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in the GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed but their overall stock status is unknown. Thus, potential combined effects of mortality, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined for bairdi Tanner and blue king crab stocks at this time under FMP 1. Potential combined effects of mortality on red king crab stocks in the GOA are considered conditionally significant adverse. These effects could further impede the recovery of the population, although the driving factor(s) behind the red king crab stocks' lack of recovery have not been determined.

Change in Biomass

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. Thus, FMP 1 would have an insignificant effect on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in the BSAI, when compared to the current baseline condition of these stocks. The level of crab bycatch predicted for 2003 through 2007 would not be expected to further impede the recovery of these already depressed stocks. Thus, the effects of FMP 1 on the change in biomass of bairdi Tanner, opilio Tanner, red king, and blue king crab are considered to be insignificant, due to the lack of significant recovery of these stocks while protective measures have been in place.

- **Persistent Past Effects.** Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in the BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey in review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have

been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. Thus, these fisheries are considered to have potential adverse effects on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI, since no signs of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock also has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole, over time. BSAI red king crab stocks do not have rebuilding plans in effect but the population is currently considered depressed. Effects of long-term climate change and regime shifts on crab biomass have not been determined.

- **Cumulative Effects.** ADF&G's crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on crab populations in the BSAI may still exist, and stocks are considered depressed with no signs of recovery to date. Thus, these combined effects resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events, are considered conditionally significant adverse. These effects could further jeopardize the sustainability of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in the BSAI under FMP 1, although the driving factor(s) behind the BSAI crab stocks' lack of recovery have not been determined.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, potential effects of FMP 1 on changes to biomass cannot be determined.

- **Persistent Past Effects.** Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in the BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries, but the composition of this catch is unknown. However, this is only applicable for the BSAI because BSAI fisheries would not influence GOA stocks. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures, providing no benefit or protection to crab stocks overall. The potential effects of past fishing mortality on biomass of golden king crab stocks in the BSAI and GOA cannot be determined because catch composition is unknown and biomass estimates over time do not exist for these stocks.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and current bycatch limits and quota-setting processes are

responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in the BSAI and GOA is unknown and biomass estimates have not been determined. Thus, the potential effects of external fisheries on biomass are not known. Effects of long-term climate change and regime shifts on crab biomass have not been determined.

- **Cumulative Effects.** ADF&G's crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on golden king crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed but the overall stock status of golden king crab in the BSAI and GOA is unknown and biomass estimates have not been determined. Thus, potential effects on biomass of BSAI and GOA golden king crab stocks, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 1.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of blue king crab in GOA, potential effects of FMP 1 on biomass of this species is unknown. Survey data collected by ADF&G for certain bairdi Tanner crab stocks in western GOA show signs of possible recovery while other GOA stocks are still considered depressed. Thus, potential effects of FMP 1 on biomass of GOA bairdi Tanner crab as a whole cannot be determined. Red king crab populations in GOA are at historic lows according to ADF&G survey information. Considering the severely depressed state of this stock as a whole, the predicted reduction in bycatch of red king crab under FMP 1 would have an insignificant effect on the biomass of these stocks when compared to the current baseline condition.

- **Persistent Past Effects.** Crab bycatch is common in certain fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Adverse effects of past fishing and unobserved mortality on biomass of bairdi Tanner, blue king, and red king crab stocks in the GOA may still exist, as recovery of depressed stocks has not occurred.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of these fisheries on biomass of bairdi Tanner and blue king crab stocks cannot be determined. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in addition to external mortality

associated with state fisheries (directed, subsistence, and scallop), could adversely impact recovery and sustainability of red king crab stocks in the GOA. Effects of long-term climate change and regime shifts on biomass have not been determined.

- **Cumulative Effects.** ADF&G's crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed but their overall stock status is unknown. Thus, potential effects on biomass of bairdi Tanner and blue king crab in the GOA, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 1. Potential effects on biomass of red king crab in the GOA are considered conditionally significant adverse. The combined effects could further impede the recovery of the population, although the driving factor(s) behind the red king crab stocks' lack of recovery have not been determined.

Change in Reproductive Success

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** These stocks are currently considered depressed and in some instances, overfished. Changes in reproductive success within BSAI crab populations may be an underlying factor in the depressed nature of these stocks. However, a direct causation between spawning-recruitment success and depressed stock status cannot be concluded at this time. Thus the potential effects of FMP 1 on changes to reproductive success cannot be determined.

- **Persistent Past Effects.** Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in the BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey in review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures, providing no benefit or protection to crab stocks overall. Thus, past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Directed crab fishing seasons are set to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in the BSAI. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock also has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab

rebuilding plan is currently being developed but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect and the population is currently considered depressed. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on crab populations in the BSAI may still exist and stocks are considered depressed with no signs of recovery to date. A relationship between spawning-recruitment success and other factors impeding on reproductive potential with depressed stock status cannot be drawn at this time, the potential effects on reproductive success, resulting from past events, direct catch, bycatch, and future events, are unknown under FMP 1.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in the BSAI and GOA, potential effects of FMP 1 on changes to reproductive success cannot be determined.

- **Persistent Past Effects.** Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in the BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries, but the composition of this catch is unknown. However, this is only applicable for the BSAI because BSAI fisheries would not influence GOA stocks. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Current stock status of BSAI and GOA golden king crab has not been determined so potential past effects on reproductive success are also unknown.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Crab seasons are set as to avoid mating and molting periods so these fisheries are not considered contributing factors to changes in reproductive success of golden king crab. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on golden king crab populations in the BSAI and GOA may exist, and internal effects are uncertain due to the lack of survey information. Potential effects on reproductive success, resulting from past events, direct catch, bycatch, and future events, are therefore, unknown for FMP 1.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of blue king crab in the GOA, potential effects of FMP 1 on changes to reproductive success cannot be determined. Survey data collected by ADF&G for certain bairdi Tanner crab stocks in western GOA show signs of possible recovery while other GOA stocks are still considered depressed. Red king crab populations in GOA are at historic lows according to ADF&G survey information. Changes in reproductive success within GOA crab populations may be an underlying factor in the depressed nature of these stocks. However, the relationship between reproductive success and depressed stock status for these stocks cannot be concluded at this time. Therefore, the potential effects of FMP 1 on changes to reproductive success cannot be determined for bairdi Tanner and red king crab populations in the GOA.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures, providing no benefit or protection to crab stocks overall. Thus, past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** Crab seasons are set as to avoid mating and molting periods so these fisheries are not considered contributing factors to changes in reproductive success of these stocks. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on crab populations in the GOA may still exist and some stocks are considered depressed with no signs of recovery to date. Because a direct causation between reproductive success and depressed stock status cannot be concluded at this time, the potential effects on reproductive success, resulting from past events, direct catch, bycatch, and reasonably foreseeable future events are unknown under FMP 1.

Change in Prey Availability

Bairdi Tanner, Opilio Tanner, Red King, Blue King, and Golden King Crab in BSAI and GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, only BSAI opilio Tanner crab is included in this analysis.

- **Direct/Indirect Effects.** Diet composition of crab has not been determined, but crab are known to be benthic feeders. Competition for prey species of crab resulting from groundfish fisheries' catch has not been shown and it is unclear if FMP 1 would impact prey structure and availability for all species of crab throughout BSAI and GOA. Thus, potential effects of FMP 1 on changes in prey availability cannot be determined.

- **Persistent Past Effects.** Crab are benthic feeders and generally feed on invertebrates. Catch of crab prey in current and past fisheries is minimal. Thus, past effects on crab prey structure and availability in the BSAI and GOA have not been identified.

- **Reasonably Foreseeable Future External Effects.** Competition for prey species of crab resulting from groundfish fisheries' catch has not been shown and these fisheries are not considered contributing factors to changes in prey availability. Rebuilding plans currently in effect in the BSAI do not address crab prey structure and availability and are not considered contributing factors to potential changes in prey availability. Long-term climate change and regime shifts may impact crab prey structure depending on the direction of the change. However, it is impossible to determine the possible effects that these changes may have on crab populations throughout BSAI and GOA.

- **Cumulative Effects.** Diet composition of crab has not been determined and potential changes to prey structure, resulting from past, present, and future events, cannot be determined for all species of crab in the BSAI and GOA.

Change in Habitat

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** These stocks are currently considered depressed and in some instances, overfished. However, a direct link between changes to habitat and the depressed stock status of these crab species in the BSAI cannot be concluded at this time. Numerous ADF&G management measures, rebuilding plans, trawl closures, and conservation areas have been implemented to address declining and overfished crab stocks in the BSAI. It is inferred that current crab management plans are mitigating past habitat disruption and providing protection for most crab stocks, thus the potential effects of FMP 1 on changes to habitat are considered insignificant.

- **Persistent Past Effects.** The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey in review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures, providing no benefit or protection to crab stocks overall. Thus, past fisheries may have directly or indirectly impacted spawning and nursery habitat areas as a result of trawling and using other types of fishing gear that interact with bottom habitat. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Although some of the known habitat areas of BSAI crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. These fisheries are considered potential adverse factors in changes to crab habitat based on the lack of recovery that has been observed for these stocks under current management plans. Formal stock rebuilding plans are in place for BSAI bairdi and opilio

Tanner crab stocks. St. Matthew Island blue king crab stock also has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed but is not in effect at this time. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole, over time, and also offer protection of critical habitat. BSAI red king crab stocks do not have rebuilding plans in effect but the population is currently considered depressed, and possible habitat-related effects have not been determined. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes that may occur.

- **Cumulative Effects.** Persistent past effects on crab habitat in the BSAI may still exist and stocks are considered depressed with no signs of recovery to date. However the relationship between changes to habitat and depressed stock status cannot be drawn at this time. Although some of the known habitat areas of BSAI crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. Thus, potential effects on crab habitat, resulting from past, present, and future events cannot be determined for FMP 1.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in the BSAI and GOA, it is difficult to identify habitat-related effects as they pertain to changes in these crab populations throughout the BSAI and GOA. Therefore, the potential effects of FMP 1 to crab habitat are unknown.

- **Persistent Past Effects.** The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures, providing no benefit or protection to crab stocks overall. Current stock status of BSAI and GOA golden king crab has not been determined so potential past effects on essential habitat are also unknown.

- **Reasonably Foreseeable Future External Effects.** Although some of the known habitat areas of the BSAI and GOA crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. These fisheries are considered potential adverse factors in possible changes to crab habitat based on the lack of recovery that has been observed for many of the crab stocks under current management plans. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes that may occur.

- **Cumulative Effects.** It is unclear if persistent past effects on golden king crab habitat in the BSAI and GOA exist. Population estimates are not available for BSAI and GOA golden crab, although some GOA golden king crab stocks are considered depressed. The relationship between habitat and depressed stock status cannot be drawn at this time. Although some of the known habitat areas of BSAI and GOA crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. Thus, the potential effects on

golden king crab habitat, resulting from past, present, and future events cannot be determined for FMP 1 without first establishing the overall population status of this species.

Bairdi Tanner, Red King, and Blue King Crab in GOA

Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, opilio Tanner crab is not included in this analysis.

- **Direct/Indirect Effects.** Red king and bairdi Tanner stocks in the GOA are currently considered depressed while blue king crab stock status is unknown, but presumed to be depressed based on limited survey data. However, the relationship between changes to habitat and depressed stock status cannot be drawn at this time. Numerous ADF&G management measures, rebuilding plans, trawl closures, and conservation areas have been implemented to address declining crab stocks in the GOA. It is inferred that current crab management plans are mitigating past habitat disruption and providing protection for crab stocks, thus the potential effects of FMP 1 on changes to habitat for bairdi Tanner, red king, and blue king crab stocks in GOA are considered insignificant.

- **Persistent Past Effects.** The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures, providing no benefit or protection to crab stocks overall. Thus, past fisheries may have directly or indirectly impacted spawning and nursery habitat areas as a result of bottom trawling. Past effects may still exist as some of these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** Although some known habitat areas of GOA crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. These fisheries are considered potential adverse factors in possible changes to crab habitat based on the lack of recovery that has been observed for these stocks under current management plans. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes to GOA crab habitat that may occur.

- **Cumulative Effects.** Persistent past effects on crab habitat in the GOA may still exist and stocks are considered depressed with no signs of recovery to date. However, the relationship between changes to habitat and depressed stock status cannot be drawn at this time. Although some of the known habitat areas of GOA crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. Thus, potential effects on GOA bairdi Tanner, red king, and blue king crab habitat, resulting from past, present, and future events cannot be determined for FMP 1.

4.5.3 Other Species Alternative 1 Analysis

The other species category consists of the following species:

- Squid (order Teuthoidea).

- Sculpin (family Cottidae).
- Shark (*Somniosus pacificus, Squalus acanthias, Lamna ditropis*).
- Skate (genera *Bathyraja and Raja*).
- Octopi (*Ocotopus dofleini, Opistholeutis california,* and *Octopus leioderma*).

An aggregate TAC limits the catch of species in this category. Within the other species category, only shark are identified to the species level by fishery observers. Furthermore, accuracy of catch estimates depends on the level of coverage in each fishery. Observer coverage in the BSAI is estimated at 70-80 percent, whereas the GOA has only approximately 30 percent observer coverage. Coverage can also vary for certain target fisheries and vessel sizes (Gaichas 2002). Management of the Other Species category is described in detail in Section 3.5.3.

Formal stock assessments for other species are not currently conducted in the BSAI and GOA and biomass estimates for the species included in this category are limited and often unreliable. Thus, changes in total biomass, reproductive success, genetic structure of population, habitat, or mortality rates under any FMP alternative cannot be determined due to lack of a baseline condition. With the exception of skates, none of the species in the other species category is currently targeted by the BSAI and GOA groundfish fisheries. Other species are only caught as bycatch by fisheries targeting groundfish. While we report changes in bycatch relative to the comparative baseline, determinations cannot be made as to how these changes in catch actually impact other species populations, or whether these impacts might be adverse, beneficial, or neutral. Numerous direct and indirect effects may impact the current and future status of individual species within this group or this group as a whole. These effects are presented in detail in the section that follows.

Direct/Indirect Effects FMP 1 – Other Species

Direct and indirect effects for other species include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups is unknown, because information on stock status is lacking in order to determine how these stocks respond to changes in catch. For many non-target species, the differences in catch between the comparative baseline and FMP 1 are relatively small, such that diverse alternatives may have similar (unknown) effects on each stock.

Under FMP 1, total catch of both BSAI squid and other species and GOA other species is predicted to increase by several thousand mt per year, due to predicted increases in catches of the target species that other species are caught with. Most of this increase is predicted in the catch of skate and sculpin in both the BSAI and GOA. Catch projections for specific groups within BSAI and GOA other species are presented below.

Squid

In the BSAI, squid catch is predicted to increase slightly and then decrease to the current level over the five projection years, likely following trends in the pollock fishery. In the GOA, squid catch is predicted to double over the five year projection period, likely reflecting increasing catches in the pollock fishery. However,

observed GOA squid catch has been low historically, so doubling may not cause different population impacts than current catch levels.

Sculpin

Catches of BSAI sculpins are predicted to increase slightly (by 500 mt relative to current catches). GOA sculpin catch is predicted to increase by 200 mt per year over the projection period.

Shark

BSAI shark species have been separated into Pacific sleeper shark, salmon shark, dogfish, and other shark. Catches of all of these species are predicted to remain stable throughout the projection period under FMP 1. As in the BSAI, shark catches in the GOA are partitioned into Pacific sleeper shark, salmon shark, dogfish, and other shark. Although all shark catch in the GOA is predicted to be relatively low, catches of other shark are predicted to increase by an order of magnitude, catches of salmon shark are predicted to decrease slightly, and catches of sleeper shark and dogfish will remain relatively similar to current levels.

Skate

Skate currently make up the largest portion of bycatch for the other species complex. The catch of BSAI skate is predicted to increase by nearly 2000 mt to over 21,000 mt within the first three projection years, and remains in that range for the remainder of the modeled period. The increased catch of skate may reflect increased catches in both longline fisheries for Pacific cod and in bottom trawl fisheries for cod and flatfish. In the GOA, skate catch is predicted to increase by about 1,300 mt, which is the same order of magnitude as current catches. This projected catch trend may warrant increased management attention if it actually occurred.

Adoption of Amendment 63 by NPFMC would result in the separation of GOA skate species from the Other Species complex. In turn, they would be added to the Target Species category with an ABC and TAC set for skates and skate complexes (NPFMC 2003a). The NPFMC has requested a separate OFL and ABC for combined Big and Longnose skates in the Central GOA due to concerns regarding a developing fishery. Efforts to address existing data gaps for skate species are underway and improved collection of data is expected under this amendment.

Octopi

Octopus catch in the BSAI is predicted to remain stable at 300-400 mt per year. Observed GOA octopus catch has been low historically, so changes to catch level may not cause different population impacts than current catch levels. The trace amounts of octopus catch reported in the GOA are predicted to decrease slightly over the projection period, with no discernable differences in the currently unknown population impacts.

Cumulative Effects FMP 1 – Other Species

A summary of the cumulative effects analysis associated with FMP 1 is shown in Table 4.5-43. For further information on persistent past effects included in this analysis, see Section 3.5.3 of this SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA other species is unknown under FMP 1. The current baseline condition is unknown and species-specific catch information is lacking for this complex since species identification does not occur in the fisheries.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA that a species or even a species group could be disproportionately exploited while the overall aggregate of other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. It is difficult to determine how much protection is afforded by a TAC set with the use of data-poor criteria.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to the specific species within this complex are unknown since current baseline condition has not been determined. Long-term climate change and regime shifts are not expected to result in direct mortality.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA other species are unknown under FMP 1. The current baseline condition is unknown and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. This possible overexploitation could have impacts to reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. However, persistent past effects on the population have not been determined.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of the other species depending on the direction of the shift. It has been

shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment but it is currently not known how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex is unknown and persistent past effects have not been identified. The combined effects of changes to reproductive success on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of the other species population in the BSAI and GOA are unknown under FMP 1. The current baseline condition is unknown, and the genetic structure of species-specific populations within this complex has not been determined.

- **Persistent Past Effects.** The current genetic composition of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. This possible overexploitation could have impacts to the genetic structure of the population if genetic composition within these species groups have been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing effects to changes in genetic structure of populations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex is unknown and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the other species complex resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA other species is unknown under FMP 1. The current baseline condition is unknown and species-specific catch information is lacking for this complex since species identification does not occur in the fisheries. Formal stock assessments are not conducted for other species and most biomass estimates for BSAI and GOA other species are unreliable or not known.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and non-specified species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to the specific species within this complex are unknown since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment but it is currently not known how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of changes in biomass on this species complex as a whole are unknown. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown.

Change in Habitat

- **Direct/Indirect Effects.** The potential effects of habitat changes to BSAI and GOA other species are unknown under FMP 1. A current baseline condition has not been determined.

- **Persistent Past Effects.** Under current management in the BSAI and GOA, impacts to habitat could be occurring for some of the species within the other species complex. However, the species included in this complex have diverse habitat preferences and distribution patterns. Although persistent past effects potentially impacting habitat for some or all of these species could exist, without a baseline condition established they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to habitat of the specific species within this complex are unknown. Long-term climate change and regime shifts are not expected to result in significant change to physical habitat and are not considered contributing factors to potential effects.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. These species also have diverse habitat preferences. Although persistent past effects potentially impacting habitat could exist, without a baseline condition established, they remain unknown. The combined effects of changes to habitat

on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown.

4.5.4 Forage Fish Alternative 1 Analysis

The BSAI and GOA FMPs were amended in 1998 to establish a forage species category to prevent the development of directed fisheries on these ecologically important non-target species. Forage fish are described in more detail in Section 3.5.4.

Direct/Indirect Effects FMP 1 – BSAI and GOA Forage Fish

Total and Spawning Biomass

Total and spawning biomass of BSAI and GOA forage fish is unknown at this time. It is thought that the effects of FMP1 are unlikely to affect biomass of forage species.

Catch/Fishing Mortality

A directed fishery on forage species is prohibited by Amendments 36 and 39 in the FMPs for the BSAI and GOA, respectively. However, forage fish are taken in small amounts as incidental catch in several target fisheries. The bulk (greater than 90 percent most years) of the forage fish bycatch, in both the BSAI and GOA, is made up of smelt species (Osmeridae) from the pollock fishery.

In the BSAI region, model projections for FMP 1 indicate incidental catch of forage fish would remain low at a level similar to the current catch (Table H.4-22 in Appendix H).

Over the next 5 years the pollock catch in the GOA is projected to grow rapidly under FMP 1 (Table H.4-41 of Appendix H). This increased pollock catch under this alternative is projected to lead to greater incidental catches of forage fish.

Spatial/Temporal Concentration of Fishing Mortality

Little is known about the current spatial or temporal concentration of fishing mortality for forage species. Spatial or temporal concentration of fishing effort is not expected to change from the current pattern under FMP 1. Consequently, there is no evidence that any change in spatial or temporal fishing mortality of forage fish would occur.

Status Determination

The MSST of forage fish species is unknown at this time but it is highly unlikely that management practices under FMP 1 would lead to stocks dropping below a sustainable level.

Age and Size Composition and Sex Ratio

The age and size composition of the species in the forage fish group is unknown. However, it is thought that FMP 1 would have little affect on the age and size composition of forage fish. The sex ratio of forage fish

is assumed to be 50:50. There is no information available that would suggest this would change under FMP 1.

Habitat-Mediated Impacts

Little is known about the relationship between forage fish and their habitat. It is unknown how any of the considered FMPs would change the suitability of the habitat occupied by forage fish.

Predation-Mediated Impacts

The predator-prey interactions of forage fish are very complex and difficult to predict. Attempting to accurately model the predator-prey impacts of different management FMPs is problematic. However, since FMP 1 is similar to the current management practices it seems unlikely that any significant changes would occur.

Summary of Effects of FMP 1 – BSAI and GOA Forage Fish

Information on forage fish species is very limited. Total biomass, spawning biomass and fishing mortality are not estimated in the model used for this analysis. Therefore, only qualitative analysis of the FMP's effects on these measures can be described.

A directed fishery for forage fish is prohibited by Amendment 36 and 39 in the BSAI and GOA FMPs. Therefore the only direct effect of FMP 1 is incidental take of forage fish in other fisheries.

The model projects future bycatch of forage fish by averaging the 1997-2001 bycatch matrix. Model output for forage fish bycatch is closely linked to pollock catch. Smelts make up the vast majority of the forage fish bycatch in the BSAI and GOA, taken mainly by the pollock fishery. Therefore, the projected level of incidental catch of forage fish is highly correlated with the pollock TAC set for the FMP.

Under FMP 1 the bycatch of forage fish in the BSAI remains consistently low at a level slightly higher than the baseline (Table H.4-22 in Appendix H). In the GOA the bycatch of forage species is projected to increase considerably in the next 5 years (Table H.4-41 in Appendix H). Although the total biomass of forage fish is unknown, the amount of incidental catch predicted for FMP 1 is thought to be a relatively small fraction of the biomass and unlikely to effect the abundance of the stock in the BSAI.

Indirect effects of FMP 1 include habitat disturbance and disproportionate removals of predators or prey. There is insufficient information to address the indirect effects of FMP 1.

Cumulative Effects FMP 1 – BSAI and GOA Forage Fish

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI and GOA forage fish is rated as insignificant under FMP 1.

- **Persistent Past Effects** have not been identified for fishing mortality in the BSAI or GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on mortality are indicated due to potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause forage fish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of forage fish. See Sections 3.5.4 and 3.10 for more information. Alaska subsistence and personal use fisheries are identified as potential adverse contributors to forage fish mortality; however, the removal of these species is expected to be minimal.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI and GOA forage fish and is rated as insignificant. Removals at projected levels are small and not expected to have a population level impact. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** The change in biomass level under FMP 1 is rated as unknown.

- **Persistent Past Effects** have not been identified for the change in biomass of the BSAI and GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on the change in biomass are indicated due to the potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause forage fish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse contributions on the forage fish biomass level. A strong Aleutian Low and increased water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts, see Sections 3.5.4 and 3.10. The Alaska subsistence and personal use fisheries have been identified as a potential adverse contributors to the change in biomass level of BSAI and GOA forage fish. Subsistence and personal use fisheries concentrate mostly on the smelt species; however, it is unlikely that these fisheries would have a population level effect.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI and GOA forage fish, but the effect is unknown. Total and spawning biomass are unavailable for the forage fish species at this time.

Spatial/Temporal Concentration of Catch

- **Direct/Indirect Effects.** Under FMP 1 the effect of the spatial/temporal concentration of catch is unknown.

- **Persistent Past Effects** are not identified for the genetic structure of the BSAI and GOA forage fish. Climate changes and regime shifts are identified as influencing the reproductive success of BSAI

and GOA forage fish. For example, some Osmeridae species have shown a decline in recruitment since the late 1970s, coinciding with the increase in water temperature.

- **Reasonably Foreseeable Future External Effects** on the reproductive success of forage fish due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI and GOA forage fish. The Alaska subsistence and personal use fisheries are identified as having potential adverse contributions to the genetic structure and reproductive success of BSAI and GOA forage species. As stated above, these fisheries mainly target smelt species; however it is unlikely the removals in these fisheries would be large enough and taken in such a localized manner that would jeopardize the capacity of the stocks to maintain current population levels.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the forage fish catch; however, this effect is unknown. Information on the spatial/temporal concentration of the BSAI and GOA forage fish bycatch is currently lacking.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 1, the change in prey availability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** are identified for the change in prey availability of the BSAI and GOA forage fish stock and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted. See Sections 3.5.4 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects** of the climate changes and regime shifts on the BSAI and GOA forage fish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stocks ability to maintain current population levels. Alaska subsistence and personal use fisheries are identified as potential adverse contributors to the prey availability of BSAI and GOA forage fish. However, the catch/bycatch of these species is expected to be minimal and unlikely to have a population level impact.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown, because the information on forage fish prey interactions is insufficient.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 1, the change in habitat suitability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** identified for BSAI and GOA forage fish include climate changes and regime shifts. A strong Aleutian Low and increased water temperatures tend to result in weak recruitment. For more information, see Sections 3.5.4 and 3.10.

- **Reasonably Foreseeable Future External Effects** of the climate changes and regime shifts on the BSAI and GOA forage fish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Alaska subsistence and personal use fisheries are identified as potential adverse contributors to forage fish habitat suitability. For more information on the effects of fishery gear on EFH, see Section 3.6.4.

- **Cumulative Effects.** A cumulative effect is identified for BSAI and GOA forage fish habitat suitability; however this effect is unknown. Information of forage fish habitat and the distribution of the fisheries on these habitats is insufficient at this time.

Summary of Cumulative Effects – BSAI and GOA Forage Fish

Although cumulative effects have been identified for mortality, change in biomass level, change in genetic structure, change in reproductive success, change in prey availability and change in habitat suitability, all effects are unknown except for mortality. Mortality has been identified as insignificant (see Tables 4.5-44 and 4.5-45).

4.5.5 Non-Specified Species Alternative 1 Analysis

Grenadiers have been chosen to illustrate potential effects to non-specified species because they are currently the major catch in the non-specified FMP category. Non-specified species make up a huge and diverse category encompassing every species not listed in the current FMP as target, prohibited, forage, or other species. Considering a single species group from this category, such as grenadier, cannot possibly represent the diverse effects to all species in the category. However, because information is lacking for nearly all of these groups, and they are caught in small or unknown amounts (due to a lack of reporting requirements in this category), we discuss potential effects to grenadier only.

Formal stock assessments are not conducted for grenadiers. Thus, changes in total biomass, reproductive success, genetic structure of population, habitat, or mortality rates under any FMP alternative cannot be determined due to lack of a baseline condition. Changes in bycatch of grenadiers were predicted based on modeled changes in target species catches and population trajectories (sablefish target fisheries have the most grenadier bycatch). While changes in bycatch relative to the comparative baseline are reported here, it is important to emphasize that determinations cannot be made as to how these changes in catch actually impact grenadier populations, or whether these impacts might be adverse, beneficial, or neutral.

Direct/Indirect Effects FMP 1 – Non-Specified Species

Direct and indirect effects for grenadier include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown, because information on stock status is lacking in order to determine how these stocks respond to changes in catch. For many non-target species, the differences in catch

between the comparative baseline and FMP 1 are relatively small, such that diverse alternatives may have similar (though unknown) effects on each stock.

Under FMP 1, catch of grenadiers in both the BSAI and GOA is predicted to remain within the currently observed range. In both areas, grenadier catch is predicted to increase slightly initially and then decrease, following trends in the sablefish fishery.

Cumulative Effects FMP 1 – Non-Specified Species

A summary of the cumulative effects analysis associated with FMP 1 is shown in Table 4.5-46. For further information on persistent past effects included in this analysis, see Section 3.5.5 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA grenadier is unknown under FMP 1. The current baseline condition is unknown and catch information is lacking for all members of the non-specified category since species identification does not occur in the fisheries.

- **Persistent Past Effects.** No management or monitoring of any species in this category exists, and retention of any non-specified species is permitted. No reporting requirements for non-specified species exist and there are no catch limitations or stock assessments. It is possible that grenadier, and all other species included in the non-specified category, in the BSAI and GOA, could be disproportionately exploited but stock status remains unknown. Grenadier continue to constitute the largest portion of the non-target species bycatch in the GOA, and mortality is therefore considered a persistent past effect.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, the state-managed commercial fisheries and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to specific species within this complex are unknown since the current baseline condition has not been determined. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** For grenadiers and other species within the non-specified complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on grenadiers, and other species with the non-specified complex, resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown for FMP 1.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA grenadiers is unknown under FMP 1. The current baseline condition is unknown for all members of the non-specified complex and species-specific catch information is lacking since species identification does

not occur in the fisheries. Formal stock assessments are not conducted and biomass estimates in the BSAI and GOA for grenadiers, other than those conducted since 1999 for the giant grenadier, are not known.

- **Persistent Past Effects.** It is possible that grenadier, and all other species included in the non-specified category, in the BSAI and GOA, could be disproportionately exploited; however, stock status remains unknown. The current non-management of grenadiers could mask declines in individual grenadier species and therefore, lead to overfishing of a given grenadier species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, potential impacts to the specific species within this complex are unknown since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of grenadiers, and all other members of the non-specified group, depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment but it is currently not known how these non-specified species would respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the non-specified species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of changes in biomass to grenadier and all other non-specified species are unknown. Although persistent past effects of changes to biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on BSAI and GOA grenadiers, and all other species in the non-specified group, resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown for FMP 1.

<u>Change in Reproductive Success</u>

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA grenadier, and presumably all other species within the non-specified complex, are unknown under FMP 1. The current baseline condition is unknown and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of grenadier is unknown. It is possible that grenadier, and all other species included in the non-specified category, in the BSAI and GOA, could be disproportionately exploited; however, stock status remains unknown. This possible overexploitation could have impacts to reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. Such overfishing could lead to reduced recruitment. It is unknown if persistent past effects on the population exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut

longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of grenadiers (and other non-specified species) depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how grenadiers, and all other members of the non-specified category, would respond to climatic fluctuations.

- **Cumulative Effects.** For grenadiers, and all other species within the non-specified category, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex are unknown and persistent past effects have not been identified. The combined effects of changes to reproductive success on grenadiers and other non-specified species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown for FMP 1.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of grenadier, and other species within the non-specified complex, populations in BSAI and GOA are unknown under FMP 1. The current baseline condition is unknown, and the genetic structure of species-specific populations within this complex has not been determined.

- **Persistent Past Effects.** The current genetic composition of the non-specified species complex is unknown. It is possible that grenadier, and all other species included in the non-specified category, in the BSAI and GOA, could be disproportionately exploited; however, stock status remains unknown. This possible overexploitation could have impacts to the genetic structure of the population if genetic composition within these species groups have been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing factors in changes to genetic structure of populations.

- **Cumulative Effects.** For grenadiers, and all members of the non-specified species category, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the non-specified species complex resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are, therefore, unknown for FMP 1.

4.5.6 Habitat Alternative 1 Analysis

Habitat protection measures under FMP 1 result from a long history of fishery management actions. The majority of historical management actions that addressed habitat concerns focused on protection of crab habitat.

Figure 4.2-1 illustrates the current suite of year-round closures in the BSAI and GOA management areas. Table 4.5-47 summarizes the baseline and FMP 1 geographic and habitat type distribution of bottom trawl closures in waters less than 1000 m. In the GOA and Aleutians Islands, nearly all of these closures are located in shallow waters (less than 100 m); near-shore state waters (GOA only), within 3 miles of sea lion rookeries, or Type I closures around Kodiak Island. In deeper areas, with the exception of the eastern GOA (area 650), only 0-7 percent of the fishable area is currently protected from the impacts of bottom trawling. In the Bering Sea most of the closures are concentrated on sand substrate believed important to crab. There are limited closures on sand/mud substrate and no closures on mud habitat. There are no closures on the upper slope of the Bering Sea, although this area is not considered by some to be a distinct habitat type (see Section 3.6 for a discussion of existing closures and their intended habitat effects).

Direct/Indirect Effects of FMP 1

Direct and indirect effects of FMP 1 are discussed for changes to living habitat through direct mortality of benthic organisms, changes to benthic community structure through benthic community diversity, and geographic diversity of impacts and protection. Due to habitat type differences, the BSAI and GOA are rated and discussed separately.

Changes to Living Habitat through Direct Mortality of Benthic Organisms

In the GOA, based on the bycatch projection model, the catch of most living habitats is projected to decline (Table 4.5-48). In the BSAI, the bycatch levels are predicted to be within about plus or minus 20 percent of the baseline. The model projections for the GOA are unrealistically low relative to the baseline. This is because specific fisheries that have high bycatch of living substrates, such as aggregated rockfish, are constrained within the model framework (Jim Ianelli, AFSC personal communication). Based on past performance, it is doubtful that such constraints will severely curtail the rockfish fishery. A more realistic assumption is that bycatch levels would be about the same as the baseline, which are at levels considered to cause adverse impacts to habitat.

The habitat impacts model predicts the following effects for biostructure relative to the baseline:

- **Bering Sea.** There is no predictable difference from the baseline. Mean impacts are low when averaged over entire fishable EEZ. As with the baseline, impacts to biostructure range from 1.8 to 9.3 percent of the fishable EEZ and from 8.2 to 41.9 percent of the fished area. A large expanse (8,000 square miles) of high fishing intensity potentially causes an 83 percent reduction in equilibrium biostructure level for scenario 2 (i.e., 15 year recovery rate). Based on these results, we conclude that change to mortality and damage to living habitat would be insignificant as a result of FMP 1. Thus the rating is based on the insignificant change between FMP 1 projections and the comparative baseline.

- **Aleutian Islands.** There is no predictable difference from baseline where mean impacts ranged from 1.1 to 6.8 percent of the fishable EEZ and from 5.4 to 32.6 percent of the fished areas. Therefore, the change resulting from FMP 1 is rated as insignificant. However, prevalence of long-lived species of coral in the bycatch makes impacts a particular concern under FMP 1. With a recovery rate for red tree coral possibly as low as $\rho = 0.005$ (200 years) and sensitivity $q_h = 0.27$, the habitat impact model indicates that fishing intensity as low as $f = 0.10$ (total area swept once every 10 years) results in an equilibrium level reduction of 85 percent relative to the unfished level. About 9 percent of the area is estimated to be fished at $f = 0.10$ or greater. This amounts to 3,590 square miles of area. Based on these results, we conclude that there would be an insignificant change to mortality and damage to living habitat as a result of FMP 1; however, as with the baseline, FMP 1 bycatch levels may have adverse consequences on habitat quality and FMP 1 would not change this risk.

- **GOA.** There is no predictable difference from the baseline where estimates of equilibrium impact on biostructure averaged over the entire fishable EEZ range from 0.9 to 6.9 percent of the fishable area and from 3.8 percent to 29.0 percent of the fished areas. Only 2 percent of the fishable EEZ is impacted to a level potentially below 32 percent (Scenario 2) of unfished levels, but this amounts to about 2,418 square miles of habitat in scattered concentrations. Therefore, for FMP 1, the change to mortality and damage to living habitat is rated as insignificant. However, as described above, the baseline condition is considered to already be adversely impacted.

Changes to Benthic Community Structure including Benthic Community Diversity and Geographic Diversity of Impacts and Protection

- **Bering Sea.** Identical to the baseline, FMP 1 closures in the Bering Sea are mostly concentrated on sand substrate (Table 4.5-47). Only 27 percent of the geographical- habitat zones have greater than or equal to 20 percent of their area closed to bottom trawling. Figure 4.1-10 shows that the amount of large contiguous areas of high fishing intensity—that is, areas that are swept at least once each year with bottom trawls—exceeds 8,000 square miles (Table 4.1-26). Table 4.5-49 shows that of the Bering Sea fishable area, 19.3 percent is closed to bottom trawling under FMP 1. However, very little geographic diversity of fishing impacts occurs within the closed habitats and nearly all of the closures are not year-round. Figure 4.5-4 shows areas closed to trawling only at various times of the year under this FMP, while Figure 4.5-5 depicts just those areas closed to fixed gear only.

Application of the habitat impacts model indicated that, depending on the sensitivity and recovery parameters thought plausible, fishing of this intensity could reduce the amount of biostructure in the area by 13 to 75 percent of its unfished equilibrium level (Table 4.1-26). Such biostructure includes sponges, soft corals, tunicates, and anemones (Heifetz *et al.* 2002, Malecha et al. 2003). In these habitat areas, no existing closure areas abut these intensely fished areas to provide a diverse level of impact. While existing closures tend to be large and cover all of particular habitat, they provide little diversity in fishing impacts. The primary focus of these past regulations has been to prevent potential damage to vulnerable crab habitat from bottom trawl gear; therefore, the closures do not necessarily cross a wide range of habitat types. Some of the trawl closures are in effect year-round while others are seasonal (see Section 3.6). Compared to the existing baseline, the predicted effects of FMP 1 on benthic community diversity are insignificant. Similarly, the predicted effects of FMP 1

on geographic diversity of impacts are also predicted to be insignificant. However, as described above for direct mortality, the baseline condition is considered to already be adversely impacted.

- **Aleutian Islands.** Identical to the baseline, FMP 1 closures in the Aleutian Islands are concentrated in shallow water where only 4 percent of the area is closed to bottom trawling year round for all species. However, as shown on Table 4.5-49, about 43 percent of the fishable area in the Aleutians is closed to bottom trawling at one time or another during the year under this FMP. These closures are associated with sea lion rookeries. As in the baseline, there is very little diversity in protection. Less than one percent of the deep area is closed to bottom trawling. Figure 4.1-10 shows that none of the closure areas extends over any blocks of significant fishing effort. Figures 4.5-4 and 4.5-5 show the closure areas under FMP 1 broken down by gear type, bottom trawl and fixed gear, respectively. The Aleutian Islands bathymetry and habitat are distributed on a very fine scale, with fishing effort that is very patchy and in very small clusters. Based on these observations as compared to the baseline, the predicted effects of FMP 1 on benthic community diversity and geographic diversity of impacts are insignificant, but the baseline condition is considered to have experienced adverse impacts.

- **GOA.** Figure 4.5-6 shows that, as in the baseline, minimal geographic diversity of impact or protection results from the current suite of closed areas. Except for the southeast trawl closure, which covers several entire habitat types, all other closures are inshore, none exist on the outer shelf or slope (see Figure 4.5-6). As shown on Table 4.5-49 and Figures 4.5-4 and 4.5-5, FMP 1 closes nearly 46 percent of the fishable area in the GOA to trawling at one time or another during the year. The inshore closure areas tend to be large relative to the size of bathymetric and habitat resolution scale and thus tend to encompass much of a bathymetric feature. Based on these results, the predicted effects of FMP 1 on benthic community diversity and geographic diversity of impacts are insignificant, but the baseline condition is considered to be in an adversely impacted state.

Cumulative Effects FMP 1

Cumulative effects on Habitat for FMP 1 are summarized on Table 4.5-50. The following discussion of the results presented on the table is broken down by geographic area.

Bering Sea

Changes to Living Habitat through Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant, but the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Bering Sea. Mortality of sessile epifauna is likely to be persistent in these areas. The areas historically and recently closed to fishing described in Section 3.6 may have recovered or be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, and marine pollution all have the potential to cause direct mortality of benthic organisms and changes

to living habitat. Offal discharge can occur from offshore catcher processors and onshore processors. However, impacts which include mortality due to smothering and/or reduced oxygen are expected to be more prevalent in inshore, closed bay locations. Improvements in offal pre-treatment and discharge regulations in recent years have reduced impacts and potentially improved conditions. Port expansion and increased use are possible at several locations in the Bering Sea area including Port Moller, Port Heiden, Dillingham, St. Paul and St. George. Again the impacts include mortality due to smothering, and/or burying and, of course, would only affect nearshore zones and bays. Marine pollution is also identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to benthic organisms. Again areas more likely to be impacted would be located nearer to shore. Natural events such as storm surges and waves also have the potential to cause direct morality through burial. These effects, like the others, would be expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organisms.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for mortality of Bering Sea benthic organisms. The additional external impacts described above will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though the effect of FMP 1 is rated as insignificant, bycatch and damage to living habitat in the Bering Sea will continue and add to the adverse consequences to benthic living habitat.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant; however, the community structure is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Bering Sea. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion). However, the areas historically and recently closed to fishing described in Section 3.6 may have recovered or be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, marine pollution, all have the potential to cause changes to benthic communities. If long-term, as in the case of a change to a weather pattern, wind-induced waves and surges could also cause sufficient changes to the substrate such that the benthic community is impacted. As discussed above, all of these impacts are more likely to be observed in nearshore areas. Regime shifts and large-scale environmental fluctuations associated with El Niño and La Niña events have been identified as having impacts on both the physical and biological systems in the North Pacific. These changes could have either beneficial or adverse effects on the benthic community (see Sections 3.6 and 3.10).

- **Cumulative Effects.** Conditionally significant adverse effects are identified for changes in benthic community structure of the Bering Sea. The additional external impacts will add to the lingering past impacts described above. The additional external impacts described above will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though the

direct/indirect effects of FMP 1 are rated as insignificant, continued bycatch and damage to living habitats in the Bering Sea will add to the adverse effects of fishing on the benthic community.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant; however, the geographic diversity is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected since fishing effort and distribution has changed over time as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 illustrate the spatial measures that were in effect before 1980 or were later established by regulations following the publication of the Final Groundfish SEIS in November of 1980. As discussed in Section 3.6, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most of the restricted areas were implemented to spatially and temporarily restrict the foreign fishery to prevent conflicts with domestic fisheries through bycatch of species important to U.S. fishermen, or grounds preemption and gear conflicts. At the time, most domestic fishing effort focused on crab, salmon, and herring. Figures 3.6-6 and 3.6-7 illustrate that in 1980, there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries. This again was due to the need to give priority to the domestic fisheries that used similar gear and fishing grounds. Table 4.5-51 shows that in 1980 almost 9 percent of the fishable area in the Bering Sea was closed to trawling with 2.2 percent closed to all fishing. There were no longline-only closures in the Bering Sea at that time.

- **Reasonably Foreseeable Future External Effects.** These include port expansion and the potential resultant changes to offal discharge and marine pollution episodes. As ports in the Bering Sea are expanded and new ports created, additional dock space for harboring the fishing fleet is made available. While the fleet might not necessarily expand, the opening of new ports may allow vessels of all sizes to access new or relatively unfished areas. On the other hand, depending on distribution, fishing pressure in heavily fished areas may be eased as access to other areas becomes available. Of course, closed areas proposed to continue under this FMP would not be affected by the redistribution of home ports. Depending on the distribution of fishing effort, previously unimpacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for changes in distribution of fishing effort. The maps and statistics discussed above show that FMP 1 would protect more benthic habitat from trawl gear in the future (19 percent) than was protected in 1980 (8.6 percent). However, the spatial distribution of the closed areas under FMP 1 will not protect the full range of habitat types, or provide for a diversity of impacts within fished areas. (Existing closures tend to be large and cover all of particular habitat, and they provide little diversity in fishing impacts since the primary focus of these past regulations has been to prevent potential damage to vulnerable crab habitat from bottom trawl gear; see internal effects discussion and baseline description in Section 3.6). The additional external impacts do not provide any protection and could add to the lingering past mortality impacts and to impacts that are already evident. This is particularly important since FMP 1 does not require a reduction in TAC. The benefits provided by

the closed areas are uncertain since previously unfished areas would likely be fished and impacts would occur in areas not previously impacted.

Aleutian Islands

Changes to Living Habitat through Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant, but the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Aleutian Islands. Prevalence of long lived species of coral makes impacts a particular concern in the Aleutians. Mortality of long lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas. The areas historically and recently closed to fishing described in Section 3.6 may have recovered or be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use and marine pollution all have the potential to cause direct mortality of benthic organisms and changes to living habitat. Dredging due to scallop fisheries and/or navigation can occur in localized areas (often in conjunction with port development) and can cause burial or smothering of benthic fauna. Damage to living substrates by longline and pot fisheries (see Section 3.6) has been documented and is expected to continue in those heavily fished areas. Offal discharge can occur from offshore catcher processors and onshore processors, causing mortality in nearshore areas. As with Bering Sea processors, improvements in offal pre-treatment and discharge regulations in recent years have reduced impacts and potentially improved conditions. Port expansion and increased use is possible at several locations in the Aleutian Islands including Atkutan, Adak, Unalaska, Cold Bay Dutch Harbor and King Cove. The impacts include mortality due to smothering, and/or burying and, would affect only nearshore zones and bays. Marine pollution is also identified as having a reasonably foreseeable potential adverse contribution, since acute and/or chronic pollution events, if large enough in scale, could cause mortality to benthic organisms. Natural events such as storm surges and waves also have the potential to cause direct morality through burial. These effects, like the others, would be expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organism.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for mortality of Aleutian Islands benthic organisms. Long lived species such as tree coral are more prevalent in the Aleutian Islands. The additional external impacts described above will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though the direct/indirect effects of FMP 1 are rated as insignificant, bycatch and damage to living habitat will continue and will add to the adverse consequences to benthic living habitat.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant; however, the community structure is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Aleutians. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may have recovered or be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline and pot fisheries, offal discharge, port expansion and use, and marine pollution, all have the potential to cause changes to benthic communities. If long-term, as in the case of a change to a weather pattern, wind-induced waves and surges could also cause sufficient changes to the substrate such that the benthic community is impacted. As discussed above for mortality, all of these impacts are more likely to be observed in nearshore areas. Regime shifts, and large-scale environmental fluctuations associated with El Niño and La Niña events have been identified as having impacts on both the physical and biological systems in the North Pacific (see Sections 3.6 and 3.10). These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for changes in benthic community structure of the Aleutians. The additional external impacts described above will add to the lingering past mortality impacts and contribute to impacts that are already evident, particularly in the case of long-lived coral species. Thus, even though the direct/indirect effects of FMP 1 are rated as insignificant, continued bycatch and damage to living habitat will add to the adverse consequences on the benthic community.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant, but the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** are expected since fishing effort and distribution have changed over time as areas have been closed and remain closed. As discussed above for the Bering Sea, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most domestic fishing effort focused on crab, salmon, and herring. Figures 3.6-6 and 3.6-7 illustrate that in 1980, there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries, in order to give priority to the domestic fisheries that used similar gear and fishing grounds. Table 4.5-51 shows that in 1980 about 31 percent of the fishable area in the Aleutians was closed to trawling with about 6 percent closed to all fishing. There were no longline-only closures in the Aleutian Islands at that time.

- **Reasonably Foreseeable Future External Effects.** These effects include other fisheries, port expansion and the potential resultant changes to offal discharge and marine pollution episodes. Depending on changes in distribution of fishing effort, sensitive areas could either additionally be

impacted or allowed to recover. As with the Bering Sea, ports in the Aleutians are expanded and new ports created, additional dock space for harboring the fishing fleet is made available. While the fleet might not necessarily expand, these additional ports and harbor space could change the distribution of fishing efforts. Of course, closed areas proposed to continue under this FMP would not be affected by the redistribution of home ports. Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by disturbance to the bottom, offal discharge and marine pollution. For example, under FMP 1, areas previously closed to foreign trawl fishing, such as Unimak Pass, are now fished by the domestic trawl fleet. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for changes in distribution of fishing effort. The maps and statistics discussed above show that FMP 1 would protect more benthic habitat from trawl gear in the future (43 percent) than was protected in 1980 (31 percent). However, the spatial distribution of the closed areas under the current FMPs will not protect the full range of habitat types, or provide for a diversity of impacts within fished areas. The additional external impacts do not provide any protection and could add to the lingering past mortality impacts and to impacts that are already evident. This is particularly important since FMP 1 does not require a reduction in TAC. The benefits provided by the closed areas are uncertain since previously unfished areas would likely be fished and impacts would occur in areas not previously impacted.

GOA

Changes to Living Habitat through Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant, but the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the GOA. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas. The areas historically and recently closed to fishing described in Section 3.6 may have recovered or be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** As described for the Bering Sea and Aleutian Islands, dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use and marine pollution all have the potential to cause direct mortality of benthic organisms and changes to living habitat. Port expansion and increased use is possible at several locations in the GOA including Kodiak, Sand Point, Chignik, Port Lions, Ouzinkie, Valdez, and Seward. The impacts, which include mortality due to smothering and/or burying, would likely only affect nearshore zones and bays. Marine pollution is also identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to benthic organisms. Natural events such as storm surges and waves also have the potential to cause direct morality through burial. These effects, like the others, would be expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organism.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for mortality of GOA benthic organisms. The additional external impacts described above will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though the direct/indirect effects of FMP 1 are rated as insignificant, bycatch and damage to living habitat will continue and add to the adverse consequences to benthic living habitat.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to be insignificant; however, the community structure is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the GOA. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may have recovered or be recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline and pot fisheries, offal discharge, port expansion and use, and marine pollution, all have the potential to cause changes to benthic communities. If long-term, as in the case of a change to a weather pattern, wind-induced waves and surges could also cause sufficient changes to the substrate such that the benthic community is impacted. As discussed above, all of these impacts are more likely to be observed in nearshore areas. Regime shifts, and large-scale environmental fluctuations associated with El Niño and La Niña events have been identified as having impacts on both the physical and biological systems in the North Pacific (see Sections 3.6 and 3.10). These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for changes in benthic community structure of the GOA. The additional external impacts described above will add to the lingering past impacts and contribute to impacts that are already evident. Thus, even though the direct/indirect effects of FMP 1 are rated as insignificant, bycatch and damage to living habitat will continue and will add to the adverse consequences to benthic living habitat.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described above in Section 4.5.6, this effect is judged to insignificant, but the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected since fishing effort and distribution have changed over time as areas have been closed and remain closed. As discussed for the other regions, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most domestic fishing effort focused on crab, salmon, and herring and there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries (Figures 3.6-6 and 3.6-7). This again was due to the need to give priority to the domestic fisheries that used similar gear and fishing grounds. Table 4.5-51 shows that in 1980 about 5 percent of the fishable area in the GOA was closed to trawling, with about 7 percent closed to all fishing. The largest closures in the GOA concerned longline

fishing where almost 61 percent of the fishable area was closed to longlining. Therefore, in 1980 about 73 percent of the fishable area in the GOA was closed to fishing of one type or another at one time or another throughout the year.

- **Reasonably Foreseeable Future External Effects.** These effects include other fisheries, port expansion and the potential resultant changes to offal discharge and marine pollution episodes. Depending on changes in distribution of fishing effort, sensitive areas could either be additionally impacted or allowed to recover. As described for the other areas, as ports in the GOA are expanded, new ports created, and additional dock space for harboring the fishing fleet is made available, and changes in the distribution of fishing effort could result. Closed areas proposed to continue under this FMP would not be affected by the redistribution of home ports. Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects.** Conditionally significant adverse effects are identified for changes in distribution of fishing effort. The maps and statistics discussed above show that FMP 1 would protect much more benthic habitat from trawl gear in the future (46 percent) than was protected in 1980 (16 percent). However, the spatial distribution of the closed areas under FMP 1 may not protect the full range of habitat types. Also, in 1980 more benthic habitat was protected from fixed gear (over 60 percent of the fishable area) than would be protected under FMP 1 (less than one percent of the fishable area in the GOA). While fixed gear impacts are believed to cause less of an impact on benthic communities, research has shown that considerable bycatch of coral and other large benthic structures occur with this gear type. The additional external impacts described above will add to the lingering impacts and contribute to impacts that are already evident. This is particularly important since FMP 1 does not require a reduction in TAC. The benefits provided by the closed areas are uncertain since previously unfished areas would likely be fished and impacts would occur in areas not previously impacted.

4.5.7 Seabirds Alternative 1 Analysis

4.5.7.1 Short-Tailed Albatross

Direct/Indirect Effects of FMP 1

Incidental Take

Incidental take of the endangered short-tailed albatross in the groundfish fishery is a very rare event, with the last recorded takes occurring in 1998 (see Section 3.7.4 for a history of takes and agency actions taken to protect this species under the ESA). The seabird protection measures on the longline fleet have been in place since 1997 and constitute the baseline condition for this analysis (see Appendix F-6). These measures have been strongly influenced by the goal of protecting short-tailed albatross. These measures did not eliminate incidental take of short-tailed albatross, as evidenced by two takes in one month in 1998. A great deal of research and development has been conducted since that time to improve the current seabird protection measures. FMP 1 would institute new protection measures based on the joint recommendations of NOAA Fisheries, USFWS, and the Washington Sea Grant Program. These new regulations are currently undergoing agency and public review before being enacted (68 FR 6386). These new regulations are

expected to substantially reduce the incidental take of all surface-feeding seabirds and therefore reduce the chance of taking short-tailed albatross. NOAA Fisheries and USFWS are currently researching the risk of short-tailed albatross incidental take due to collisions with trawl third wires. FMP 1 would incorporate any mitigation measures that arise from this research if it is considered necessary to protect the species.

Given the extreme rarity of short-tailed albatross, numbering less than 2,000 birds worldwide, any level of mortality is a conservation concern. For this reason, management actions that substantially reduce the chance of human-caused mortality even if the chance is not totally eliminated, have been pursued under the ESA and are included under FMP 1. From the perspective of research, management, and fishing industry efforts to reduce the chance of taking short-tailed albatross, the new protection measures have been very substantial. However, the short-tailed albatross population has been increasing at a near-maximum rate under the baseline conditions so a reduced chance of mortality in the fishery, when the measurable frequency of that mortality already approaches zero, may not result in measurable benefits for the population. The reduced level of incidental take under FMP 1 is therefore considered to be insignificant at the population level for short-tailed albatross.

Changes in Food Availability

Short-tailed albatross forage over vast areas of ocean on prey that are taken only in negligible amounts by the groundfish fisheries and which do not appear to be affected on an ecosystem level by the groundfish harvest (see Sections 4.5.4 and 4.5.10). Short-tailed albatross are therefore unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 1. FMP 1 is therefore considered to have insignificant effects on short-tailed albatross.

Benthic Habitat

Short-tailed albatross are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 1. FMP 1 is therefore considered to have no effects on short-tailed albatross.

Cumulative Effects of FMP 1

The past/present effects on short-tailed albatross are described in Section 3.7.4 (Table 3.7-12) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-52.

Mortality

- **Direct/Indirect Effects.** Under FMP 1, new seabird protection measures on the longline fleet should substantially reduce the chances of taking short-tailed albatross incidentally in the groundfish fishery, although the risk would not be eliminated. Incidental take of short-tailed albatross is therefore predicted to be a very rare event in the groundfish fishery and is considered insignificant at the population level.

- **Persistent Past Effects.** The most important persistent influence on the short-tailed albatross population is their near extinction due to commercial feather hunting from the late 1800s to 1932 (Hasegawa and DeGange 1982). Conservation efforts in Japan and the U.S. have helped secure and expand nesting locations and reduce human-caused mortality factors such as incidental take in fisheries, allowing the population to recover at or near to its biologically maximum rate. Given the lack of observers and incidental take data from most of the fisheries in their range, the total fishery-related mortality of short-tailed albatross is unknown. However, considering their recent rate of population growth, overall mortality does not appear to be having an overriding effect on the population.

- **Reasonably Foreseeable Future External Effects.** The primary concern for the future of the species' complete recovery is the risk presented by volcanic eruptions on their main breeding site, Torishima Island. If a major eruption occurred while the birds were nesting, a significant proportion of the breeding adults could be killed along with their eggs/chicks. Such a disaster would not cause the species' extinction, since many non-breeding birds would be at sea and there are alternative nesting sites, but it would place even greater importance on each human-caused mortality, no matter how rarely it occurred. It may lead to further efforts to protect the species from fishery interactions. The recovery rate of the species will also depend on maintaining a very low incidental take rate for all fisheries in their range. Major expansions in fishing effort, changes in gear types, or creation of new fisheries could lead to small changes in overall incidental take that could have measurable population level effects.

- **Cumulative Effects.** Since the population of short-tailed albatross is susceptible to several natural and human-caused mortality factors that may or may not occur in the future, including incidental take in the groundfish fisheries under FMP 1, the cumulative effect on short-tailed albatross is considered to be conditionally significant adverse at the population level.

<u>Changes in Food Availability</u>

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a very small amount of squid and forage fish as bycatch under FMP 1. This effect is considered insignificant at the population level for short-tailed albatross. While groundfish vessels contribute to overall marine pollution through accidental spills and vessel accidents, the effects of this pollution on short-tailed albatross prey populations cannot be assessed at this time.

- **Persistent Past Effects.** Short-tailed albatross primarily prey on squid and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to natural fluctuations in primary productivity and oceanographic factors. Pollution from a variety of land and marine sources have potentially affected short-tailed albatross prey in the past but specific toxicological effects are unknown.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on short-tailed albatross prey availability. The collapse of the short-tailed albatross population was due to direct harvest rather than loss or change of habitat. The growth rate of the population should therefore not be limited by the carrying capacity of the

environment, which once supported millions of birds, in the foreseeable future. Pollution is likely to affect short-tailed albatross prey in the future but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey to short-tailed albatross, cannot be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of short-tailed albatross prey is considered to be insignificant at the population level.

Benthic Habitat

Since short-tailed albatross feed at the surface and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect on benthic habitat is identified for short-tailed albatross.

4.5.7.2 Laysan Albatross and Black-Footed Albatross

Direct/Indirect Effects of FMP 1

Incidental Take

The incidental take of Laysan and black-footed albatross are reported in the Observer Program data from 1993-2001 and include the unidentified albatross and an unknown number of the unidentified tubenoses (Tables 3.7-1 through 3.7-5). The number of albatross taken under the baseline condition of seabird protection measures can be estimated from the 1997-2001 data since these measures were implemented in 1997. The estimated number of Laysan albatross taken in this period averaged 650 birds per year in the BSAI longline sector (including a share of the unidentified albatross category), 126 birds per year on GOA longlines, and 90 birds per year (mean of low and high estimates) in the BSAI and GOA trawls, for a total estimated average take of 866 birds per year in the groundfish fishery. The latest population estimate for the species is 2.4 million birds (Cousins *et al.* 2000). Mortality from the groundfish fishery under the baseline conditions is thus estimated at 0.04 percent of the population and is therefore considered insignificant. For black-footed albatross, estimated mortality in the groundfish fisheries averaged 12 birds per year in the BSAI longline sector (including a share of the unidentified albatross category) and 158 birds per year on GOA longlines (with no observed takes in the BSAI and GOA trawls), for a total estimated average take of 170 birds per year in the groundfish fishery. The latest population estimate for the species is 300,000 birds (Cousins and Cooper 2000). Mortality from the groundfish fishery under the baseline conditions is thus estimated at 0.06 percent of the population and is therefore considered insignificant.

The baseline seabird protection measures for longline vessels were developed in large part to protect short-tailed albatross but were based on the deterrence of northern fulmars and the albatross species in this group (see Appendix F-6 for a discussion of the effectiveness of the present seabird protection measures). Similarly, the new seabird protection measures that would be enacted under FMP 1 (68 FR 6386) were based in part on the substantial reduction of incidental take of Laysan and black-footed albatross using paired tori lines (Melvin *et al.* 2001). NOAA Fisheries is currently in the process of finalizing the new seabird deterrent regulations for the longline fleet. However, most of the BSAI freezer longline fleet and many smaller vessels in the GOA began using the new seabird deterrent devices on a voluntary basis during the 2002 fishing

season. Incidental take data from the 2002 season should therefore give some indication of the potential effectiveness of the new regulations in reducing take of albatross. Seabird incidental take data are reported in the annual SAFE, Ecosystems Considerations Report. Data from the 2002 season will be available in the 2003 SAFE (NPFMC 2003b) (see Comment Analysis Report for updated statistics and analysis).

NOAA Fisheries and USFWS are currently researching the potential impact of incidental take due to collisions with trawl third wires. FMP 1 would incorporate any mitigation measures that arise from this research if it appears to reduce the chances of incidentally taking short-tailed albatross. This assessment would likely be made on the basis of a measured reduction in the take of Laysan albatross in lieu of short-tailed albatross, as was done for the longline protection measures. Potential future mitigation of take from trawl third wire collisions would therefore reduce incidental take of Laysan albatross and perhaps black-footed albatross as well.

While the management measures proposed under FMP 1 can be justified by various statutory conservation directives and would be expected to reduce the incidental take of albatross relative to the baseline condition, the level of incidental take for these species under the baseline conditions is considered to be insignificant at the population level.

Changes in Availability of Food

Albatross forage over vast areas of ocean on prey that are taken only in negligible amounts by the groundfish fisheries and which do not appear to be affected on an ecosystem level by the groundfish harvest (see Forage Fish and Ecosystem Sections 4.5.4 and 4.5.10). Albatross are therefore unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 1. FMP 1 is therefore considered to have insignificant effects on albatross.

Benthic Habitat

Albatross are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 1. FMP 1 is therefore considered to have no effects on these species.

Cumulative Effects of FMP 1

The past/present effects on these albatross species are described in Sections 3.7.2 and 3.7.3 (Tables 3.7-6 and 3.7-7) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above (Table 4.5-53). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way.

Mortality

- **Direct/Indirect Effects.** Under FMP 1, new seabird protection measures for the BSAI/GOA longline fleet (Section 3.7.1) would be expected to substantially reduce the contribution of this fishery to the overall mortality of albatross. Expected incidental take of both species is considered insignificant at the population level.

- **Persistent Past Effects.** Both of these albatross species have been subjected to various human-caused mortality factors in the past, including hunting on their nesting colonies and incidental take in net and longline fisheries. For black-footed albatross, estimated incidental take in U.S. and foreign North Pacific longline fisheries has exceeded the maximum amount of anthropogenic mortality (10,000 birds per year) that can be sustained by a stable population according to population modeling (Cousins and Cooper 2000). Census data from their breeding grounds in Hawaii indicate an overall decline in population of 1.3 percent per year over the past decade (NMFS 2001d). The great majority of past mortality has been in the foreign longline fleets (estimated at approximately 20,000 birds per year) while the Hawaiian longline fleet has taken an average of 1,700 birds per year and the BSAI/GOA groundfish fisheries have averaged about 250 birds per year since 1997.

  Laysan albatross have been taken in huge numbers in the past by feather hunters and in fisheries. Numbers of breeding pairs in Hawaii have declined substantially in the past decade. Since Laysan albatross have a conservative life history strategy that depends on high adult survival rates, mortality of adults in fisheries (or any other source) can have delayed and lingering adverse effects on the population. While some major sources of mortality have been eliminated (feather hunting ended in the 1930s, high-seas driftnet fishing ended in 1991), incidental take in longline fisheries has been substantial in the recent past. Applying the results of the black-footed albatross population model as an approximation for Laysan albatross, the threshold of maximum anthropogenic mortality that could be sustained by a stable population would be about 80,000 birds per year (3.3 percent of the estimated population). Mortality rates less than this value could also have measurable population level effects by reducing the rate of recovery from a decline, especially during periods of poor reproductive success such as might occur from oceanic regime shifts. Foreign North Pacific longline fisheries have taken an estimated 15,000 Laysan albatross per year while the Hawaiian pelagic longline fisheries took an average of 1,330 birds per year and the BSAI/GOA groundfish fisheries took an average of about 770 birds per year on longlines. There are no reliable incidental take data from other North Pacific longline fisheries such as the halibut fisheries. A smaller number of Laysan albatross were taken in groundfish trawls and were killed in vessel strikes. The numbers of Laysan albatross killed in similar trawl and net fisheries throughout their range is unknown. The known mortality from these fisheries adds up to less than one percent of the estimated population and does not appear to be enough to account for the observed decline in Hawaiian breeding pairs. A number of other factors may be partly responsible for the decline, including lingering effects from high-seas driftnet mortality, mortality from acute and chronic effects of pollution such as plastics and toxic compounds, underestimated mortality in all fisheries, and higher than normal rates of natural mortality (i.e. starvation). It is not known what combination and proportion of factors are responsible for the observed population decline.

- **Reasonably Foreseeable Future Effects.** New seabird protection measures have recently been established for the Hawaiian pelagic longline fleets and are expected to reduce take of albatross in those fisheries. The United Nations Committee on Fisheries established an international plan for reducing seabird bycatch in longline fisheries (FAO 1999) that calls on member states to voluntarily develop guidelines or regulations for their fisheries. However, these national plans are likely to be inconsistent in their efficacy and enforcement in the foreseeable future. It is therefore expected that incidental take of black-footed and Laysan albatross in foreign longline fisheries will remain high and will continue to exceed the threshold for population level effects.

- **Cumulative Effects.** Since the populations of black-footed and Laysan albatross are undergoing measurable declines and several human-caused mortality factors have been identified and are expected to continue in the future, including contributions from the groundfish fisheries under FMP 1, the cumulative effects on black-footed and Laysan albatross are considered to be significantly adverse at the population level.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a very small amount of squid and forage fish as bycatch under FMP 1. This effect is considered insignificant at the population level for both albatross species. While groundfish vessels contribute to overall marine pollution through accidental spills and vessel accidents, the effects of this pollution on seabird prey populations cannot be assessed at this time.

- **Persistent Past Effects.** Albatross primarily prey on squid and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to climate and oceanographic factors. Since albatross can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources has potentially affected albatross prey in the past. However, very little is known about the specific toxicological effects on prey species important to these albatross or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on albatross prey availability. Pollution is likely to affect albatross prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey to albatross, cannot be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of albatross prey is considered to be insignificant at the population level for all species.

Benthic Habitat

Since albatross feed at the surface or with shallow dives and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect is identified for these species.

4.5.7.3 Shearwaters

Direct/Indirect Effects of FMP 1

Incidental Take

The incidental take of shearwaters is reported in the Observer Program data from 1993-2001, including an unknown number of the unidentified tubenoses (Tables 3.7-1 through 3.7-5). The number of shearwaters taken under the baseline condition of seabird protection measures can be estimated from the 1997-2001 data

since these measures were implemented in 1997. The estimated mortality of shearwaters in the groundfish fisheries averaged 578 birds per year in the BSAI longline sector, 18 birds per year on GOA longlines, and 799 birds per year (mean of low and high estimates) in the BSAI and GOA trawls, for a total estimated average take of 1395 birds per year in the groundfish fishery. Population estimates of short-tailed and sooty shearwaters are 23 million and 30 million birds, respectively (Everett and Pitman 1993, Springer *et al.* 1999). Incidental take of these species in the groundfish fisheries under the baseline conditions is much less than 0.01 percent of their populations and is thus considered insignificant.

The new seabird protection measures that would be enacted under FMP 1 (68 FR 6386) were developed in large part to protect short-tailed albatross and were based on the substantial reduction of incidental take of other albatross using paired tori lines (Melvin *et al.* 2001). However, shearwaters are able to dive deeper than albatross and the new deterrent devices did not change the rate of incidental take of these species. NOAA Fisheries and USFWS are currently researching the potential impact of incidental take due to collisions with trawl third wires. FMP 1 would incorporate any mitigation measures that arise from this research if it appears to reduce the chances of incidentally taking short-tailed albatross. It is not clear at this point whether shearwaters are also susceptible to collisions with trawl gear or whether any potential mitigation measures for albatross would reduce incidental take of shearwaters as well. Although the seabird protection measures proposed under FMP 1 may not reduce incidental take of shearwaters, there is no indication that they would increase take of these species. Since the level of incidental take for both shearwater species is considered to be insignificant under the baseline conditions, incidental take under FMP 1 is also considered to be insignificant at the population level for both shearwater species.

Changes in Food Availability

Shearwaters forage over vast areas of ocean on planktonic prey that are taken only in negligible amounts by the groundfish fisheries and which do not appear to be affected on an ecosystem level by the groundfish harvest (see Forage Fish and Ecosystem Sections 4.5.4 and 4.5.10). Shearwaters are therefore unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 1. FMP 1 is therefore considered to have insignificant effects on shearwaters through availability of food.

Benthic Habitat

Shearwaters are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 1. FMP 1 is therefore considered to have no effects on these species through benthic habitat.

Cumulative Effects of FMP 1

The past/present effects on both shearwater species are described in Section 3.7.6 (Table 3.7-14) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above (Table 4.5-54). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-54.

Mortality

- **Direct/Indirect Effects.** Under FMP 1, new seabird protection measures for the BSAI/GOA longline fleet (Section 3.7.1) would not be expected to reduce the contribution of this fishery to the overall mortality of shearwaters. Expected incidental take of both species is considered insignificant at the population level.

- **Persistent Past Effects.** Both species of shearwaters have been subjected to various human-caused mortality factors in the past, including hunting on their nesting colonies and incidental take in net and longline fisheries. Sooty and short-tailed shearwaters are so abundant and so widespread in the Pacific Ocean that it is very difficult to estimate their populations and hence very difficult to determine if their populations are fluctuating in response to any set of conditions. Chicks of both species have been and are likely to continue to be harvested in massive numbers on their breeding grounds for both subsistence and commercial purposes. Many other fisheries throughout their huge range have taken them incidentally, although the total number of these mortalities is unknown. This situation is likely to continue in the future. The number of shearwaters taken in the BSAI/GOA groundfish fisheries has been relatively small (about 600 birds per year in the longline fisheries and about 800 birds per year in trawls). There is some evidence to suggest that both populations may be declining on their breeding grounds but the scope and mechanisms for these declines have not been established.

- **Reasonably Foreseeable Future Effects.** New seabird protection measures have recently been established for the Hawaiian pelagic longline fleets that are similar to those proposed for the Alaskan fisheries. These measures are not expected to reduce incidental take of shearwaters in those fisheries. The United Nations Committee on Fisheries established an international plan for reducing seabird bycatch in longline fisheries (FAO 1999) that calls on member states to voluntarily develop guidelines or regulations for their fisheries. However, these national plans are likely to be inconsistent in their efficacy and enforcement in the foreseeable future. It is therefore expected that incidental take of shearwaters in foreign longline and trawl fisheries will likely continue as in the past unless longline and trawl deterrence techniques are developed and applied that are effective for diving species.

- **Cumulative Effects.** Since the populations of shearwaters may be undergoing declines and several human-caused mortality factors have been identified and are expected to continue in the future, including contributions from the groundfish fisheries under FMP 1, the cumulative effects on sooty and short-tailed shearwaters are considered to be conditionally significant adverse at the population level.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a very small amount of squid as bycatch under FMP 1. This effect is considered insignificant at the population level for both shearwater species. While groundfish vessels contribute to overall marine pollution through accidental spills and vessel accidents, the effects of this pollution on shearwater prey populations cannot be assessed at this time.

- **Persistent Past Effects.** Short-tailed and sooty shearwaters are susceptible to periodic widespread food shortages that have caused massive die-offs in Alaskan waters. Natural fluctuations in primary productivity and oceanographic factors are considered to be the driving forces that determine the abundance of their main prey (euphausiids) rather than competitive interactions with other predators. Since shearwaters can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources have potentially affected shearwater prey in the past. However, very little is known about the specific toxicological effects on prey species important to these species or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on shearwater prey availability. Pollution is likely to affect shearwater prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey to shearwaters, cannot be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of shearwater prey is considered to be insignificant at the population level for all species.

Benthic Habitat

Since shearwaters feed at the surface or with shallow dives and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect is identified for these species.

4.5.7.4 Northern Fulmar

Direct/Indirect Effects of FMP 1

Incidental Take

Northern fulmars make up a majority of all birds taken in all three gear sectors. The numbers of fulmars taken are reported in the Observer Program data under their own species listing plus an unknown number of the unidentified tubenoses and unidentified seabird groups (Tables 3.7-1 through 3.7-5). The number of fulmars taken under the baseline condition of seabird protection measures can be estimated from the 1997-2001 data since these measures were implemented in 1997. The estimated number of fulmars taken in this period averaged 10,689 birds per year in the BSAI longline sector, 406 birds per year on GOA longlines, 3,083 birds per year (mean of low and high estimates) in the BSAI and GOA trawls, and 42 birds per year in BSAI and GOA pots, for an estimated average identified take of 14,220 birds per year in the groundfish fishery. This total does not include any portion of the "unidentified seabird" category in the data set or any estimate of birds killed by vessel strikes. Given the high proportion of fulmars in the identified categories, one could reasonably assume that a large number of the unidentified bird remains were actually fulmars. For this analysis, the portion of unidentified birds in the data that were actually fulmars will be approximated as an additional 1,000 birds per year, mostly from the BSAI longline sector. Vessel strike data have been collected in an *ad hoc* manner but existing records indicate that an average of at least 80 fulmars are killed each year by trawl third wires (NOAA Fisheries is currently researching the nature and extent of this mortality factor). Adding these approximations to the identified fulmar takes gives a total estimated average take of about

15,300 birds per year from all fisheries. The latest population estimate for fulmars in the BSAI and GOA is about 2 million birds, with 4 to 5 million in the North Pacific (Hatch and Nettleship 1998). Mortality from the groundfish fishery is thus equal to about 0.76 percent of the BSAI and GOA population.

This level of incidental take is considered to be insignificant at the overall population level. However, because fulmars only breed in a few large colonies in the BSAI/GOA, there is some concern that incidental take from the fisheries could have a colony level effect if a disproportionate amount of the overall take comes from only one colony, particularly the Pribilof Islands since it is the smallest colony. The USFWS has established permanent sample plots on the Pribilof Islands but the usefulness of those census plots to measure potential colony level changes of fulmars is questionable (see Section 3.7.5). The U.S. Geological Survey/Biological Resource Division (USGS/BRD) has recently begun to research the issue using satellite telemetry and genetic analysis to determine the movement patterns of fulmars and the colony of provenance of birds taken in the fishery. Other factors that may cause population levels to fluctuate, including variable environmental conditions, will be investigated as well.

The baseline seabird protection measures for longline vessels were developed in large part to protect short-tailed albatross but were based on the deterrence of northern fulmars and other albatross species since they behave in a similar manner around fishing vessels (see Appendix F-6 for a discussion of the effectiveness of the present seabird protection measures). Similarly, the new seabird protection measures that would be enacted under FMP 1 (68 FR 6386) were based in part on the substantial reduction of incidental take of fulmars and albatross using paired and single tori lines (Melvin *et al.* 2001). Although NOAA Fisheries is currently in the process of finalizing the new seabird deterrent regulations, many longline vessels have already adopted the paired and single tori line techniques on a voluntary basis and the numbers of birds taken per 1000 hooks has been decreasing since 2001. These new regulations are expected to result in a substantial overall reduction in take of fulmars, partly due to the effectiveness of the new techniques in deterring surface-feeding species and partly due to the inclusion of performance standards in the new regulations that were not included in the baseline. Since most of the BSAI freezer longline fleet and many smaller vessels in the GOA began using the new seabird deterrent devices on a voluntary basis during the 2002 fishing season, incidental take data from the 2002 season should give some indication of the potential effectiveness of the new regulations in reducing take of fulmars. Incidental take data are reported in the annual SAFE, Ecosystems Considerations Report. Data from the 2002 season will be available in the 2003 SAFE (NPFMC 2003b) (see Comment Analysis Report for updated statistics and analysis).

As described in the albatross section above, FMP 1 would incorporate any mitigation measures that arise from current research on incidental take from trawl third wires. Management actions under FMP 1 would therefore be expected to substantially reduce overall incidental take of fulmars relative to the baseline condition. Since the amount of incidental take for fulmars under the baseline conditions is considered to be insignificant at the population level, the reduced level of take under FMP 1 is therefore considered to be insignificant at the population level for fulmars.

Changes in Food Availability

Fulmars forage over vast areas of ocean on prey that are taken in very small amounts by the groundfish fisheries and which do not appear to be affected on an ecosystem level by the groundfish harvest (see Forage Fish and Ecosystem Sections, 4.5.4 and 4.5.10). Fulmars are therefore unlikely to be affected by any potential

localized disturbance or depletion of prey from the fishery as managed under FMP 1. FMP 1 is therefore considered to have insignificant effects on fulmars.

Benthic Habitat

Fulmars are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 1. FMP 1 is therefore considered to have no effects on this species.

Cumulative Effects of FMP 1

The past/present effects on northern fulmars are described in Section 3.7.5 (Table 3.7-13) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above (Table 4.5-55). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-55.

Mortality

- **Direct/Indirect Effects.** Under FMP 1, new seabird protection measures for the BSAI/GOA longline fleet (Section 3.7.1) would be expected to substantially reduce the incidental take of fulmars in the groundfish fishery. Expected incidental take is considered insignificant at the population level.

- **Persistent Past Effects.** Fulmars have probably been taken incidentally in every net and longline fishery in the North Pacific but there are very little data on the magnitude of that overall mortality. Incidental take in the BSAI/GOA groundfish fisheries appears to be the largest source of human-caused mortality for fulmars in this area with an estimated average of over 15,000 birds per year from all gear sectors. Although fulmars are very abundant (estimated 2 million in the BSAI/GOA) and there is no indication of an area-wide population decline, there is some concern that particular colonies, especially on the Pribilof Islands, may be experiencing declines related to the groundfish fisheries. Other potential mortality factors that have been identified include acute and chronic effects of pollution, underestimated mortality in all fisheries, and higher than normal rates of natural mortality (i.e. starvation) due climatic and oceanographic fluctuations.

- **Reasonably Foreseeable Future Effects.** Incidental take of fulmars is expected to continue in all offshore fisheries in the BSAI/GOA. The IPHC fisheries will be subject to the same new seabird avoidance measures as the groundfish longline fleet so incidental take from the halibut and sablefish fleet is expected to decline substantially. Future oil spills and other incidents of pollution are likely but their effects on fulmars will depend on many factors that cannot be predicted.

- **Cumulative Effects.** Since the population of northern fulmars appears to be stable and the primary human-caused mortality factors, including contributions from the groundfish fisheries under FMP 1, are expected to decline in the future, the cumulative effects on fulmars are considered to be insignificant at the population level.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a very small amount of forage fish and pelagic invertebrates as bycatch under FMP 1. This effect is considered insignificant at the population level for northern fulmars. While groundfish vessels contribute to overall marine pollution through accidental spills and vessel accidents, the effects of this pollution on fulmar prey populations cannot be assessed at this time.

- **Persistent Past Effects.** Fulmars prey on squid and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to climate and oceanographic factors. Since fulmars can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources have potentially affected fulmar prey in the past. However, very little is known about the specific toxicological effects on species important to fulmars or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on fulmar prey availability. Pollution is likely to affect fulmar prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey to fulmars, cannot be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of fulmar prey is considered to be insignificant at the population level.

Benthic Habitat

Since fulmars feed at the surface or with shallow dives and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernible effect on their prey. Therefore, no cumulative effect is identified for these species.

4.5.7.5 Species of Management Concern (Red-Legged Kittiwakes, Marbled and Kittlitz's Murrelets)

Direct/Indirect Effects of FMP 1

Incidental Take

The population of red-legged kittiwakes is estimated at around 150,000 birds, almost 80 percent of which nest on St. George Island in the Pribilofs. The combination of their restricted breeding area and substantial declines on permanent census plots led to their classification as a USFWS species of management concern. Red-legged kittiwakes have a separate species code in the Observer Program data on incidental take and may also be reported under the "gull" category and potentially under "unidentified seabirds" (Tables 3.7-1 through 3.7-5). Between 1993 and 2001, no specified red-legged kittiwakes were recorded as taken in the BSAI and GOA groundfish fisheries.

The proposed new seabird avoidance measures that would be adopted under FMP 1 are expected to substantially reduce the incidental take of surface-feeding seabirds such as red-legged kittiwakes. Since the incidental take of red-legged kittiwakes is apparently already very rare (if it occurs), a reduced level of take would be considered insignificant at the population level. The effects of FMP 1 on red-legged kittiwakes through incidental take are therefore considered insignificant.

Marbled and Kittlitz's murrelets are species of management concern in Alaska due to recent dramatic declines in their numbers in core habitats in southeast Alaska. Both of these species have separate species codes in the Observer Program data and may also be reported under the "alcids" and perhaps the "unidentified seabird" groups. No marbled or Kittlitz's murrelets have been specifically reported taken in the observed groundfish fisheries between 1993 and 2001 Tables 3.7-1 through 3.7-5). Given their nearshore preferences and non-gregarious behavior, it is unlikely that murrelets are taken regularly in any of the BSAI/GOA groundfish fisheries. Since alcids are taken so infrequently on longlines, seabird avoidance measures for longlines would likely not affect the incidental take of murrelets. Therefore, the effects of FMP 1 on marbled and Kittlitz's murrelets through incidental take are considered insignificant at the population level.

Changes in Food Availability

Red-legged kittiwakes consume several species of small schooling fish as well as zooplankton. Given the wide variety of foods used by kittiwakes and the extensive areas over which they forage, it seems unlikely that they are very susceptible to localized depletion of prey during the non-breeding season. However, while nesting, kittiwakes are more limited in their options and are more susceptible to localized depletions of prey around their colonies. The existing ban on the development of a commercial forage fish fishery would be maintained under FMP 1 and is considered to be beneficial to seabirds by preventing a potentially adverse fishery from developing. The species and size classes of forage fish and zooplankton that red-legged kittiwakes consume are taken only in negligible amounts by the groundfish fisheries. The abundance and distribution of these prey species do not appear to be affected on an ecosystem level by the groundfish harvest under the baseline conditions (see Sections 4.5.4 and 4.5.10). Since the structure and intensity of the fishery under FMP 1 would be very similar to the baseline condition, FMP 1 is considered to have insignificant effects on the availability of food for red-legged kittiwakes.

Marbled and Kittlitz's murrelets forage in shallow waters within 5 kilometers (km) of shore and feed on small fish such as capelin and Pacific sandlance as well as zooplankton and other invertebrates. The groundfish fisheries have very little spatial overlap with murrelet foraging areas and, as described above for kittiwakes, appear to have insignificant effects on the abundance and distribution of these prey species. Overall, the effects of FMP 1 on the availability of prey for murrelets would be considered insignificant.

Benthic Habitat

Red-legged kittiwakes are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 1. Marbled and Kittlitz's murrelets feed on species that depend on benthic habitats for at least part of their life cycles. However, benthic habitats in their nearshore foraging areas would not be affected directly by groundfish trawls under FMP 1 as these take place further offshore. FMP 1 is therefore considered to have insignificant effects on marbled and Kittlitz's murrelets, and no effects on red-legged kittiwakes.

Cumulative Effects of FMP 1

The past/present effects on red-legged kittiwakes, marbled murrelets, and Kittlitz's murrelets are described in Sections 3.7.13 and 3.7.17 (Tables 3.7-22 and 3.7-26) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above (Table 4.5-56). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-56.

Mortality

- **Direct/Indirect Effects.** Under FMP 1, new seabird protection measures for the BSAI/GOA longline fleet (Section 3.7.1) would be expected to substantially reduce the incidental take of surface-feeding seabirds such as red-legged kittiwakes. Since the incidental take of red-legged kittiwakes is apparently already very rare (if it occurs), a reduced level of take would be considered insignificant at the population level. Murrelets would be much more likely to be taken in trawls than longlines but no takes of either species have been recorded by groundfish observers. Incidental take of murrelets is therefore considered insignificant at the population level.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include subsistence hunting and egging (red-legged kittiwakes), incidental take in coastal salmon gillnet and other net fisheries (murrelets), oil spills (murrelets), and logging of nest trees (marbled murrelets). Incidental take in the BSAI/GOA groundfish fisheries appears to have contributed very little to the mortality of these species.

- **Reasonably Foreseeable Future Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future. Conservation concerns for red-legged kittiwakes focus on potential impacts around the Pribilof Islands during the nesting season since 80 percent of the population is concentrated in time and space. For this reason, the introduction of nest predators or a large oil spill could have significant effects on mortality. While these potentially catastrophic events could happen at any time, several laws and programs are in place to mitigate the likelihood of them occurring.

  For the murrelet species, human impacts in nearshore habitats from the GOA to southeast Alaska will likely have a much greater effect on their populations than offshore fisheries. The largest sources of human-caused mortality from the past, oil spills and incidental take in salmon and other State net fisheries, are likely to remain the largest factors in the future. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may also contribute to future mortality. If the Kittlitz's murrelet population continues to decline and the species is listed under the ESA, new regulations may be placed on the various nearshore net fisheries to monitor and reduce incidental take of the species. These measures would also benefit marbled murrelets.

- **Cumulative Effects.** The three species in this group have all experienced substantial population declines in the recent past and are all susceptible to future human-caused mortality factors, including potentially small contributions from the groundfish fishery. The decline of red-legged kittiwakes on the Pribilofs may have been reversed recently but it is not clear if their recovery will continue in the future. The cumulative effect for red-legged kittiwakes is therefore considered conditionally

significant adverse at the population level. Both murrelet species continue to decline in their core areas and are thus considered to have significantly adverse cumulative effects at the population level.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a small amount of forage fish and pelagic invertebrates as bycatch under FMP 1. The effect of the fishery on the abundance and distribution of seabird prey species is considered insignificant at the population level for all three species in this group. While groundfish vessels contribute to overall marine pollution and disturbance, the effects of vessel hazzards on seabird prey populations cannot be assessed at this time.

- **Persistent Past Effects.** All three species prey on small schooling fishes and an assortment of invertebrates that have been targeted or taken as bycatch by external fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be small compared to climate and oceanographic factors. Pollution from a variety of land and marine sources, including the EVOS, have likely affected the prey of these species in the past. Since murrelets are easily disturbed by marine vessels of all kinds, high concentrations of vessel traffic in some areas may have effectively excluded murrelets from certain important foraging areas.

- **Reasonably Foreseeable Future External Effects.** Future squid and herring fisheries as well as other net fisheries that take forage fish as bycatch may have an effect on prey availability for these species. Pollution is also likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey on a scale important to the birds, cannot be made at this time.

- **Cumulative Effects.** While the groundfish fisheries are considered to have an insignificant effect on prey availability on their own, the dynamic interaction of natural and human-caused events, including fisheries and pollution, on the availability of forage fish and invertebrate prey to seabirds is only beginning to be explored with directed research. Since this dynamic could conceivably be adverse or beneficial depending on different circumstances, the cumulative effect on prey availability is considered to be unknown for these three species.

Benthic Habitat

No cumulative effect is identified for red-legged kittiwakes because they are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of the groundfish fishery. Marbled and Kittlitz's murrelets feed on species that depend on benthic habitats for at least part of their life cycles but they forage in shallow waters that are inshore of the groundfish fishery. Since the groundfish fishery would not contribute to potential effects on benthic habitats important to murrelets the cumulative effect is considered insignificant.

4.5.7.6 Other Piscivorous Species (Most Alcids, Gulls, and Cormorants)

Direct/Indirect Effects of FMP 1

Incidental Take

The incidental take of species considered in this piscivorous group is reported in the Observer Program data under the gull, alcid, and "other" categories, as well as an unknown number of the "unidentified seabird" category (Tables 3.7-1 through 3.7-5). The number of piscivores taken under the baseline condition of seabird protection measures can be estimated from the 1997-2001 data since these measures were implemented in 1997. The estimated number of gulls taken in this period averaged 3,268 birds per year in the BSAI longline sector, 147 birds per year on GOA longlines, and 274 birds per year (mean of low and high estimates) in the BSAI and GOA trawls, for an estimated average take of 3,689 birds per year in the groundfish fishery. Even if a large proportion of the unidentified seabirds are gulls, this level of mortality is considered insignificant at the population level given the combined estimated abundance (2.5 million birds) of the different gull species in the BSAI and GOA (Table 3.7-21).

For the alcids, mortality from the groundfish fishery comes almost entirely from the trawl sector and averaged 259 birds per year (mean of low and high estimates) in the BSAI/GOA trawls. Given the estimated abundance of large alcids in these waters (approaching 20 million, Table 3.7-21), this level of mortality is considered insignificant at the population level. Incidental take of cormorants would be included in the "other" category, which approaches zero and is therefore considered an insignificant level of mortality at the population level.

The new seabird protection measures for the longline fleet that would be instituted under FMP 1 (68 FR 6386) would be expected to result in a substantial overall reduction in take of surface-feeding species such as gulls. This is a substantial management and fishery action and is considered an improvement relative to the baseline level of mortality. Since the amount of incidental take for gulls under the baseline conditions is considered to be insignificant at the population level, the reduced level of take under FMP 1 is therefore considered to be insignificant at the population level for gulls.

Changes in Food Availability

Food consumption by seabirds depends not only on forage stocks in their feeding areas, but also on the availability of these stocks to the birds. The availability of prey to piscivorous seabirds is affected by a number of oceanographic and biological factors (see Section 3.7.1) that may vary substantially over short time periods and distances. The question of whether the intensity and structure of the groundfish fishery under the baseline condition has adverse or beneficial effects on the availability of forage fish for seabirds has not been addressed through directed research. Many of the data gaps identified in Section 5.1.2.8 address this issue. Although there are very little empirical data on how a fishery might affect the availability of forage fish to seabirds, it is assumed that fishing (with trawl gear at least) could disrupt the movements and structure of forage fish schools such that they would be less available to seabirds, at least for a short period of time. Localized depletion or disruption of prey species around seabird colonies could be particularly detrimental during the chick-rearing period for breeding seabirds. However, most species can forage up to 40 km from their colonies during chick-rearing with a few species ranging to 100 km so any localized and short term disruptions of forage fish would have negligible effects at the population level. The existing ban on the

development of a commercial forage fish fishery (BSAI/GOA FMP Amendments 36/39) is considered to be beneficial to seabirds by preventing a potentially adverse fishery from developing. This ban would be maintained under FMP 1. The species and size classes of forage fish (and zooplankton) that piscivorous seabirds feed on are taken only in negligible amounts by the groundfish fisheries. The abundance and distribution of seabird prey does not appear to be affected on an ecosystem level by the groundfish harvest (see Sections 4.5.4 and 4.5.10). The baseline condition of groundfish harvest is therefore considered to have insignificant effects on the availability of food for piscivorous seabirds.

The fisheries provide an artificial yet nutritious supplement to seabird diets in the form of processing waste and offal. No studies have been conducted in Alaska on whether this food source provides a significant benefit to the survival rate or reproductive success of any species on the population or colony level. It is likely that the value of this supplemental food varies over time and space, fluctuating with the availability of natural food supplies and seasonal nutritional needs. Whereas some birds may benefit from the food supply provided by offal and processing waste, such waste also acts as an attractant that may lead to increased incidental take in fishing gear. In addition, some species, such as the large gulls, tend to be more successful at competing for fish scraps at vessels and processors and may thus receive a greater nutritional boost than the smaller species. Since the large gulls are also nest predators of other species, especially kittiwakes and murres, the supplemental food from fishery wastes may be beneficial to some species and detrimental to others within this species group. Thus, this indirect effect of the fishery potentially has both beneficial and adverse effects on seabirds and the net benefit or liability is unknown.

Under FMP 1, the structure and intensity of the fishery would be similar to the baseline condition, which is considered to have an insignificant effect on piscivorous seabird populations. FMP 1 would also maintain the ban on development of a directed forage fish fishery. For these reasons, FMP 1 is considered to have insignificant effects on food availability for piscivorous species.

Benthic Habitat

Cormorants and alcids have diverse diets that include both small schooling fishes (capelin and sand lance) as well as demersal fish species and crustaceans. These birds are capable of diving from 40 m to over 100 m deep and are thus able to reach the ocean floor in many areas. Some species, such as cormorants and guillemots, usually forage in coastal waters during the breeding season, but other species forage well away from land. Bottom trawl gear has the greatest potential to indirectly affect these diving seabirds via physical changes to benthic habitat but pelagic trawls (to various extents), pot gear, and longline gear also contact the ocean floor. Trawling (and to a lesser extent other fishing gear disturbance) can reduce habitat complexity and productivity (NRC 2002). Specific effects of trawling on seabird prey species in the BSAI/GOA (through habitat change rather than by direct take) are poorly known (see Sections 3.6 and 5.1.2.7 on EFH for a discussion of research needed to address data gaps in benthic habitat changes due to trawling). However, none of the species in this group appears to have experienced consistent or widespread population declines so there is no indication that the carrying capacity of the environment has been decreased through changes to benthic habitat (or any other mechanism). Overall trawl effort in the BSAI/GOA under FMP 1 will remain very similar to the baseline condition. The effect of FMP 1 on piscivorous seabirds through potential changes in benthic habitat is therefore considered insignificant at the population level.

Cumulative Effects of FMP 1

The past/present effects on the species in this group, including most alcids, gulls, and cormorants, are described in the species accounts of Section 3.7 (Tables 3.7-16 and 3.7-20) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above (Table 4.5-57). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-57.

Mortality

- **Direct/Indirect Effects.** Under FMP 1, new seabird protection measures for the BSAI/GOA longline fleet (Section 3.7.1) would be expected to substantially reduce the incidental take of surface-feeding seabirds such as gulls but not of diving species such as alcids. Incidental take of all species in this group is considered insignificant at the population level under FMP 1.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include subsistence hunting and egging, incidental take in a variety of foreign and U.S. coastal and pelagic fisheries, oil spills and other pollution, fox farming, and regime shifts that have caused episodes of mass starvation. Incidental take in the BSAI/GOA groundfish fisheries appears to have contributed relatively little to the mortality of these species.

- **Reasonably Foreseeable Future Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future except for fox farming. A similar, though unintentional, effect is the possible introduction of nest predators (i.e. rats) to seabird colonies. Conservation concerns focus on preventing potential impacts around breeding colonies during the nesting season since populations are concentrated in time and space. For some species, human impacts in nearshore habitats will likely have a much greater effect on their populations than offshore fisheries. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may also contribute to future mortality.

- **Cumulative Effects.** Although a number of past and future human-caused mortality factors, including potentially small contributions from the groundfish fishery, have been identified for the species in this group, none of these species have experienced substantial, consistent, or area-wide population declines in the recent past. The cumulative effects for these species are therefore considered insignificant at the population level.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a small amount of forage fish and pelagic invertebrates as bycatch under FMP 1. The effect of the fishery on the abundance and distribution of seabird prey species is considered insignificant at the population level for all species in this group. While groundfish vessels contribute to overall marine pollution and disturbance, the effects of vessel hazzards on seabird prey populations cannot be assessed at this time.

- **Persistent Past Effects.** All species in this group prey on small schooling fishes and an assortment of invertebrates that have been targeted or taken as bycatch by external fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be small compared to climate and oceanographic factors. Pollution from a variety of land and marine sources, including the EVOS, have likely affected the prey of these species in the past. Since some of the alcids are easily disturbed by marine vessels of all kinds, high concentrations of vessel traffic in some areas may have effectively excluded them from certain important foraging areas.

- **Reasonably Foreseeable Future External Effects.** Future foreign squid and forage fish fisheries as well as other net fisheries that take forage fish as bycatch may have an effect on prey availability for these species. Pollution is also likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey on a scale important to the birds, cannot be made at this time.

- **Cumulative Effects.** The groundfish fisheries contribute to the dynamic interaction of natural and human-caused events that affect the availability of forage fish and invertebrate prey to seabirds. While this dynamic is only beginning to be explored with directed research, the lack of substantial, consistent, or area-wide population declines in these species indicates that the baseline conditions do not have an overriding adverse effect on the natural fluctuations of these seabird populations. Since no new major contributing factors are expected in the future under FMP 1, the cumulative effect on prey availability is considered insignificant at the population level for these species.

<u>Benthic Habitat</u>

- **Direct/Indirect Effects.** Bottom trawls, and to a lesser extent pelagic trawls and pot gear, have the potential to modify benthic habitats and have indirect effects on the food web of diving piscivorous species. The overall effects of FMP 1 on piscivorous seabirds through potential changes in benthic habitat are considered insignificant.

- **Persistent Past Effects.** Benthic habitats important to the diving species in this group, including the alcids and cormorants, have been affected by various foreign and U.S. fisheries for many years and include nearshore as well as offshore fisheries. The magnitude and longevity of the effects of these different types of fisheries have only begun to be investigated so it is unclear what or where habitat effects are persistent, especially in regard to the indirect effects on prey species important to seabirds. Natural sources of benthic habitat disruption, such as strong ocean currents, ice scouring, and foraging by gray whales and walrus, may also have persistent effects in certain areas.

- **Reasonably Foreseeable Future External Effects.** All future fisheries in the BSAI/GOA that use bottom contact fishing gear are likely to affect benthic habitat to some extent. Natural sources of benthic habitat disruption will also continue.

- **Cumulative Effects.** The groundfish fisheries contribute to the many human-caused and natural factors that alter benthic habitats important to the food web of piscivorous seabirds. While there has been limited research on specific effects of benthic habitat disturbance on seabirds, the lack of substantial, consistent, or area-wide population declines in these species indicates that the baseline

conditions do not have an overriding adverse effect on the natural fluctuations of these seabird populations. Since no new major contributing factors are expected in the future under FMP 1, the cumulative effect on benthic habitat is considered insignificant at the population level for these species.

4.5.7.7 Other Planktivorous Species (Storm-Petrels and Most Auklets)

Direct/Indirect Effects of FMP 1

Incidental Take

Leach's and fork-tailed storm-petrels are not identified to species in the Observer Program data but they do have an "unidentified storm-petrel" code and may be reported in the "unidentified tubenoses," "other," and "unidentified seabird" categories (Tables 3.7-1 through 3.7-5). The numbers of storm-petrels in these categories are unknown but likely to be small given their feeding behavior. Given the abundance of these species in the BSAI/GOA area, with a combined population estimate of over 10 million birds (Table 3.7-21), incidental take of storm-petrels under the baseline conditions is considered to be insignificant at the population level. Although some of the planktivorous auklets have individual species codes in the Observer Program data, they are reported in the "alcid" and "unidentified seabird" categories. It is unlikely that they are taken on longlines at all and probably constitute only a small fraction of the trawl take. Given their abundance in the BSAI/GOA, with a combined population of over 10 million birds (Table 3.7-21), incidental take of auklets under the baseline conditions is considered to be insignificant at the population level.

Another means of incidental take in the fishery is by birds striking the vessel or rigging. The Observer Program does not record vessel strikes on a systematic basis so data on the frequency or extent of such strikes are very limited (NPFMC 2003b). Crested auklets do not seem to strike fishing vessels very frequently but when they do, the incidents often involve large numbers of birds. According to preliminary analysis of the observer records of bird-strikes from 1993-2000, 1,305 crested auklets were involved in 7 recorded collisions. In one historical account, approximately 6,000 crested auklets were attracted to lights and collided with a fishing vessel near Kodiak Island during the winter of 1977 (Dick and Donaldson 1978). Storm-petrels are also prone to periodic collisions involving many birds (631 birds in 19 recorded incidents). Bird strikes are probably most numerous during the night and during storms or foggy conditions when bright deck lights are on, which can cause the birds to be disoriented. Given the sporadic nature of these collisions and the small numbers of birds involved relative to their overall populations, the effect of the fisheries on these species through vessel collisions is considered insignificant at the population level under the baseline conditions. Since fishing effort under FMP 1 would be similar to the baseline, the effect of FMP 1 on incidental take from vessel collisions is considered insignificant.

Changes in Food Availability

Storm-petrels are relatively small surface feeding seabirds that primarily target zooplankton and juvenile fish. The auklets feed on zooplankton (euphausiids), juvenile fish, and squid. The abundance and distribution of these prey species are affected by a number of oceanographic and biological factors (see Section 3.7.1) that may vary substantially over short time periods and distances. The groundfish fisheries could indirectly affect the availability of zooplankton and small schooling fish to seabirds through changes in the abundance and distribution of target fish species that also prey on small fish and zooplankton. For example, since young

pollock are planktivores, large changes to pollock populations as a result of fishing could theoretically affect the carrying capacity for storm-petrels and auklets. However, zooplankton and juvenile fish abundance and distribution are thought to be influenced much more by primary productivity and oceanographic fluctuations (bottom-up factors) than predator/prey relationships (top-down factors) (see Section 4.5.10). Since the structure and intensity of the fisheries managed under FMP 1 would be similar to the baseline conditions, the effects of FMP 1 on the availability of prey are considered to be insignificant at the population level for planktivorous seabirds.

Benthic Habitat

Storm-petrel and auklets are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 1. FMP 1 is therefore considered to have no effects on these species.

Cumulative Effects of FMP 1

The past/present effects on the species in this group, including storm-petrels and most auklets, are described in Sections 3.7.7 and 3.7.18 (Tables 3.7-15 and 3.7-27) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above (Table 4.5-58). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-58.

Mortality

- **Direct/Indirect Effects.** Under FMP 1, new seabird protection measures for the BSAI/GOA longline fleet (Section 3.7.1) would be expected to substantially reduce the incidental take of surface-feeding seabirds such as storm-petrels but not of diving species such as auklets. However, it is likely that more birds of these species die from occasional vessel strikes than are taken in any groundfish fishing gear. Incidental take of all species in this group are considered insignificant at the population level under FMP 1.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include subsistence harvest, incidental take in foreign and U.S. coastal and pelagic fisheries, oil spills and other marine pollution, fox farming, and regime shifts that have caused episodes of mass starvation. Incidental take in the BSAI/GOA groundfish fisheries appears to have contributed relatively little to the mortality of these species.

- **Reasonably Foreseeable Future Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future except for fox farming. A similar, though unintentional, effect is the possible introduction of nest predators (i.e. rats) to seabird colonies. Conservation concerns focus on preventing potential impacts around breeding colonies during the nesting season since populations are concentrated in time and space. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may also contribute to future mortality.

- **Cumulative Effects.** Although a number of past and future human-caused mortality factors, including potentially small contributions from the groundfish fishery, have been identified for the

species in this group, none of them have experienced substantial, consistent, or area-wide population declines in the recent past. The cumulative effects for these species are therefore considered insignificant at the population level.

Changes in Food Availability

- **Direct/Indirect Effects.** The influence of the groundfish fisheries on the abundance and distribution of zooplankton and juvenile fish is limited to indirect effects on the abundance of target fish that prey on the same things the seabirds eat. This potential influence is considered minor compared to seasonal changes in primary productivity and oceanographic factors. The effect of the fishery on the abundance and distribution of seabird prey species is considered insignificant at the population level for all species in this group under FMP 1.

- **Persistent Past Effects.** Zooplankton and juvenile fish have been taken in very small amounts as bycatch in squid and forage fish fisheries but their influence on abundance is probably negligible compared to natural fluctuations. Commercial whaling in the early 1900s decimated the populations of several planktivorous whales that competed with seabirds for prey. This release from competitive pressure may have had long-term beneficial effects on planktivorous seabird populations.

- **Reasonably Foreseeable Future External Effects.** Future squid and herring fisheries as well as other net fisheries that take forage fish as bycatch may have minimal effects on prey availability for these species. Pollution is also likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey on a scale important to the birds, cannot be made at this time.

- **Cumulative Effects.** The groundfish fisheries contribute in an indirect way to human influences on planktonic prey availability, which are considered minimal compared to natural fluctuations. These cumulative effects are considered insignificant on the population level for all species in this group.

Benthic Habitat

Since these planktivorous seabirds feed at the surface or with shallow dives, and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect is identified for these species.

4.5.7.8 Spectacled Eiders and Steller's Eiders

Direct/Indirect Effects of FMP 1

Incidental Take

Spectacled eiders interact very little, if at all, with the groundfish fisheries because most of the habitat for this species is located in the northern Bering Sea or in inshore areas of northwest Alaska. Although spectacled eiders have an individual species code in the Observer Program manual, no spectacled eiders have

been observed to be taken in any of the fisheries since data collection began in 1993. Thus the groundfish fisheries have no effect on spectacled eiders.

The winter distribution of Steller's eiders does include areas where groundfish fisheries occur although these birds prefer shallow, nearshore waters. There is some overlap between the fisheries and Steller's eider critical habitat in the northwestern portion of Kuskokwim Bay (Kuskokwim Shoals). Only two vessels fished this area in 2001, both over 200 ft LOA so there was 100 percent observer coverage. Steller's eiders have an individual species code in the Observer Program manual but no incidental takes have been documented since 1995 (Tables 3.7-1 through 3.7-5). Based on the very minimal overlap between the predicted fisheries under FMP 1 and these two eider species, FMP 1 is considered to have insignificant effects on the population level through incidental take.

Changes in Food Availability

The abundance of marine invertebrate species important to the spectacled and Steller's eiders, including bivalves, snails, crustaceans, and polychaete worms, could potentially be affected by disturbance to their benthic habitat. These effects will be discussed below. The groundfish fisheries catch only negligible amounts of these species and are unlikely to affect their abundance or distribution through ecosystem level effects under the baseline conditions (see Section, 4.5.10). Since the fishery under FMP 1 is also predicted to have a minimal overlap with Steller's eider habitat, the effects of FMP 1 on prey abundance for Steller's eider species (separate from potential benthic habitat effects) are considered insignificant at the population level. As, discussed above, the groundfish fisheries do not overlap in space or time with spectacled eider critical habitat and therefore, have no effect on spectacled eider food availability.

Benthic Habitat

Gear impacts on benthic habitat used by spectacled and Steller's eiders would primarily be from bottom trawl gear although pelagic trawls and pot gear also make contact with the bottom and contribute to benthic disturbance. Trawling (and to a lesser extent other fishing gear disturbance) can reduce habitat complexity and productivity (NRC 2002). The effects of trawl gear on benthic habitat are discussed in the EFH sections of this document (Sections 3.6.4 and 4.5.6). Based on an analysis of the Observer Program data, no overlap occurred between spectacled eider critical habitat and the groundfish fishery under the baseline conditions. Since FMP 1 is predicted to have a similar structure and intensity as the baseline, there are no predicted effects on spectacled eider benthic habitat.

Since Steller's eiders forage almost exclusively in shallow waters inshore of the groundfish fisheries, their preferred winter habitats are not subject to groundfish fishing effort. During the breeding season, the overlap of bottom trawl fisheries and Steller's eider critical habitat is also very limited, involving only a few vessels in a limited area of Kuskokwim Bay (Kuskokwim Shoals, NPFMC 2003b). The effects of this small bottom trawl fishery on Steller's eider critical habitat have not been investigated but considering the limited fishing effort and large area of critical habitat that is not fished, it is unlikely that the changes in benthic habitat resulting from this fishery would affect Steller's eiders on a population level. During Section 7 consultations with NOAA Fisheries, USFWS also concluded that the fisheries were not likely to affect Steller's eiders (USFWS 1992). Under FMP 1, the Kuskokwim Bay fishery is expected to continue in approximately the same area and intensity as under the baseline conditions. The overall effect of FMP 1 on the benthic habitat of Steller's eider is therefore considered to be insignificant at the population level.

Cumulative Effects of FMP 1

The past/present effects on spectacled and Steller's eiders are described in Sections 3.7.9 and 3.7.10 (Tables 3.7-17 and 3.7-18) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above (Table 4.5-59). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-59.

Mortality

- **Direct/Indirect Effects.** Spectacled eiders do not overlap in time and space with the groundfish fisheries and are not expected to have any incidental take under FMP 1. Steller's eiders overlap with the fisheries to a limited extent but incidental take has been and is expected to continue to be very rare. Incidental take of Steller's eiders is therefore considered to be insignificant at the population level under FMP 1.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include subsistence harvest, incidental take in Russian and Alaskan coastal fisheries, oil spills and other marine pollution, and lead shot poisoning on the nesting grounds. Incidental take in the BSAI/GOA groundfish fisheries appears to have been very rare for Steller's eider. Both species have been afforded protection through the ESA.

- **Reasonably Foreseeable Future Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future. Conservation concerns focus on preventing potential impacts in critical habitat areas.

- **Cumulative Effects.** The groundfish fisheries do not contribute to direct mortality of spectacled eiders so no cumulative effect is identified for that species. Human-caused mortality of Steller's eider, including very rare incidental take in the groundfish fisheries, does not appear to account for the past population decline in Alaska. Since the population may have stabilized and known human-caused mortality is very low, the cumulative effects of mortality on Steller's eiders are considered insignificant at the population level.

Changes in Food Availability

The abundance of marine invertebrate species important to the spectacled and Steller's eiders, including bivalves, snails, crustaceans, and polychaete worms, could potentially be affected by disturbance to their benthic habitat. These effects will be discussed below. Although other factors external to the fisheries may influence the abundance and distribution of Steller's eider prey, the groundfish fisheries have a minimal contribution to these potential effects. Therefore, an insignificant cumulative effect on prey availability is identified for Steller's eiders. There are no cumulative effects identified for spectacled eider food availability since there are no direct/indirect impacts from the groundfish fisheries.

Benthic Habitat

- **Direct/Indirect Effects.** Bottom trawls, and to a lesser extent pelagic trawls and pot gear, disrupt benthic habitats that support the prey of eiders. Under FMP1, the groundfish fishery is not expected to occur in spectacled eider critical habitat or any other area that they typically use. A limited amount of bottom trawling is expected to overlap with Steller's eider critical habitat. The overall effects of FMP 1 on Steller's eiders through potential changes in benthic habitat are considered insignificant at the population level.

- **Persistent Past Effects.** Benthic habitats important to spectacled and Steller's eiders have been affected by various trawl and pot fisheries for many years and include nearshore as well as offshore fisheries. The magnitude and longevity of the effects of these different types of fisheries have only begun to be investigated so it is unclear what or where habitat effects are persistent, especially in regard to the indirect effects on prey species important to eiders. Natural sources of benthic habitat disruption, such as strong ocean currents, ice scouring, and foraging by gray whales and walrus, may also have persistent effects in certain areas.

- **Reasonably Foreseeable Future Effects.** All future fisheries that use bottom contact fishing gear in areas used by eiders are likely to affect benthic habitat to some extent. Natural sources of benthic habitat disruption will also continue.

- **Cumulative Effects.** While the groundfish fisheries are predicted to have little spatial overlap with eider habitat under FMP 1, the interaction of human-caused and natural disturbances of benthic habitat important to Steller's eiders has not been examined with respect to their population declines in the past. The cumulative effects of benthic habitat disruptions over the years as they relate to the food web important to Steller's eiders are therefore considered to be unknown. There are no identified effects on spectacled eiders' benthic habitat because no direct/indirect impacts from the groundfish fisheries have been identified.

4.5.8 Marine Mammals Alternative 1 Analysis

4.5.8.1 Western Distinct Population Segment of Steller Sea Lions

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

With regard to incidental take, FMP 1 is not likely to result in significant changes to the population trajectory of the western distinct population segment (western population) of Steller sea lions. An average of 8.4 Steller sea lions from the western population was estimated to have been taken incidental to groundfish fisheries from 1995 to1999 (Angliss *et al.* 2001) (Table 4.5-60). In this context, incidental take refers to animals which are deceased or have injuries that are expected to result in the death of the animal. The ratio of observed takes of Steller sea lions to observed groundfish catch (from 1995 to 1999) was multiplied by the new projected groundfish catch (all fisheries combined) to estimate incidental takes expected to occur over the next six years under this alternative management regime. The estimated annual incidental take level of Steller sea lions under FMP 1 in all areas combined is expected to be less than ten based on expected catch in this

alternative, or about one sea lion per 220,000 mt of groundfish harvested. Incidental bycatch frequencies in the BSAI, which are typically low, reflect locations where fishing effort was highest. In the Aleutian Islands and GOA, incidental takes are often within critical habitat, though in the Bering Sea such bycatch is farther off shore and along the continental shelf. Otherwise there seems to be no apparent "hot spot" of incidental catch disproportionate with fishing effort. Therefore, it is appropriate to estimate take ratios based on estimated catch. However, if these take rates differ between observed and unobserved vessels then these take estimates would be biased accordingly. These rates also reflect a prohibition of trawling within ten or 20 nm of 37 rookeries which likely reduces the potential for incidental take, particularly during the breeding season when females are on feeding trips within the critical habitat area.

Entanglement of Steller sea lions in derelict fishing gear or other materials seems to occur at frequencies that do not have significant effects on the population. From a sample of rookeries and haul-out sites in the Aleutian Islands in which 15,957 adults were observed, Loughlin *et al.* (1986) found only 11 (0.07 percent) entangled in marine debris, some of which was derelict fishing gear. Observations of sea lions at Marmot Island for several months during the same year observed two out of 2,200 adults (0.09 percent) entangled in marine debris. Between 1993 and1997, only one fishery-related stranding was reported from the range of the western population: a sea lion observed in August 1997 with troll gear in its mouth and down its throat (Angliss *et al.* 2001). Entanglement of sea lions in derelict fishing gear or other marine debris does not appear to present a significant threat to the population.

The Marine Mammal Protection Act (MMPA) requires NOAA Fisheries (NMFS Office of Protected Resources) to assess whether human-caused mortality threatens the stability or recovery of any species of marine mammal. The MMPA defines a measurement tool for this purpose, the potential biological removal (PBR), that is a calculated value of the maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or maintain its optimum sustainable population. This calculation takes into consideration the most recent population estimates, historic population trends, status of the stock in relation to historic levels (i.e. whether it is depressed or not), and potential rates of recovery. According to the most recent stock assessment, PBR for the western population of Steller sea lions is 208 animals per year (Angliss and Lodge 2002). Mortality from incidental take and entanglement in marine debris is likely to continue under FMP 1 at levels that are small (less than ten percent) relative to PBR and is therefore considered insignificant according to the criteria set for significance (Table 4.1-6).

Fisheries Harvest of Prey Species

Changes in the fishing mortality rates for Steller sea lion prey species were calculated using output from the multi-species management model which projected catch rates for the various alternatives. The estimated fishing mortality rates expected to occur under each alternative management regime were compared to the baseline fishing mortality rate in order to apply the significance criteria established in Table 4.1-6 for determining effects of the FMPs on marine mammal populations. The baseline fishing mortality rates for the individual BSAI and GOA groundfish fisheries, the fishing mortality rates projected to occur under each FMP, and the relative difference between the baseline and FMP fishing mortality rates are shown in Table 4.5-61.

Under FMP 1, the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 22 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals, the change in the harvest of this key Steller sea lion prey species is rated as significant. It is worth noting that the harvest rate of pollock in the EBS was abnormally low in 2002. This low harvest rate was due

to the high abundance of commercially sized pollock in the EBS which resulted in a large recommended ABC for this population. By definition, ABC is set annually at a level deemed to be biologically acceptable based on the status and dynamics of the population, environmental conditions, and other ecological factors (e.g., natural mortality). The baseline groundfish FMPs contain catch provisions referred to as OYs that limit the total amount of BSAI and GOA groundfish harvest. Unlike the ABC, which is applied to individual species or species groups, the OY limit applies to the entire complex of commercially important species as well as other species with lesser or no commercial importance in each management region. In 1981, the OY for total BSAI groundfish catch was set as a range from 1.4 to 2.0 million mt. In 2002, the recommended ABC for pollock in the EBS was greater than the OY and was therefore capped to stay within the OY range. Because the 2002 EBS pollock TAC was capped by the OY ceiling, F was lower than that deemed to be biologically acceptable. Therefore, in relative terms, subsequent increases in F expected to occur under FMP 1 for EBS pollock may not result in significantly adverse effects to predators in terms of the biomass of prey available, despite being categorized as such under the established significance criteria.

The fishing mortality rate of GOA pollock is expected to increase by an average of one percent relative to the comparative baseline over the next five years under FMP 1. This change in F is insignificant at the population level for Steller sea lions. Fishing mortality rates are not calculated for Aleutian Islands pollock as there was no directed Aleutian Islands pollock fishery under the baseline condition. There is no change in the projected catch of Aleutian Islands pollock between the baseline and FMP 1 and therefore effects of Aleutian Islands pollock harvests are deemed to be insignificant to Steller sea lions at the population level.

Under FMP 1, BSAI and GOA Pacific cod fishing mortality rates are expected to increase by 20 percent and decrease by 17 percent, respectively. These combined changes are insignificant to Steller sea lions according to the criteria established in Table 4.1-6. Changes in Aleutian Islands Atka mackerel harvest are expected to be significantly adverse to Steller sea lions with a 60 percent increase in F relative to the baseline.

Little difference is expected relative to the baseline for harvest of other non-target species that are prey for Steller sea lions (e.g., cephlapods and forage fish such as capelin). Changes in the harvest of these species under FMP 1 were determined to be insignificant to Steller sea lions.

The comparative baseline conditions include all Steller sea lion protection measures that were adopted in 2001 (NMFS 2001a). These include provisions to protect prey resources such as area closures, critical habitat harvest limits on prey species, gear and TAC restrictions, and a modified global harvest control rule to prohibit fishing when spawning biomass per recruit is reduced to 20% of the unfished level. With these controls, the combined harvest of prey was found to not jeopardize the continued existence of the western populations of Steller sea lions (NMFS 2001a). Harvest levels under FMP 1 would be similar to the 2002 baseline conditions and are thus considered insignificant to the western population of Steller sea lions.

Spatial/Temporal Concentration of the Fishery

The criterion used to evaluate the spatial/temporal effects of the groundfish fisheries on marine mammal populations is that the alternative FMP would be expected to result in either increased or decreased spatial/temporal concentrations in key marine mammal foraging areas and periods such that prey resources are altered to the extent that population-level effects would be expected to occur. The spatial/temporal measures in FMP 1 were designed with the objective of reducing competitive interactions between groundfish fisheries and Steller sea lions in their key foraging areas during periods that are believed to be critical to Steller sea lions. Opportunistic sightings of Steller sea lions (sightings reported ancillary to other

activities, such as surveys for other species, fishing, or shipping) indicate that Steller sea lions occur in offshore areas where protective measures designed to reduce fishing and sea lion interactions have not been instituted (POP 1997). The potential for competitive interaction between groundfish fisheries and Steller sea lions exists in areas that are not managed with seasonal or spatial fishery closures, but where sea lions are known to occur. Under the baseline conditions, such potential interactions are thought to be reduced by overall groundfish harvest limits, also referred to as "global controls." Additionally, groundfish fisheries have been dispersed in time and space under the baseline conditions, so that the competitive interactions with Steller sea lions are thought to be mitigated to a level that is not expected to jeopardize the continued existence of the western population of Steller sea lions or appreciably reduce the likelihood of their survival and recovery in the wild (NMFS 2001b). Spatial and temporal fishing measures in FMP 1 do not deviate from the baseline; thus, the effects of the spatial/temporal concentration of the fisheries under FMP 1 are determined to be insignificant to Steller sea lions according to the criteria established in Table 4.1-6.

Disturbance

With regard to disturbance are existing management measures minimize nearshore disturbance of Steller sea lions. In particular, the prohibition of vessel entry within 3 nm of major rookeries avoids intentional and unintentional hazing of hauled out sea lions or those aggregated near shore. A total of 3,250 square kilometer (km^2) around 36 sites is offered this protection.

What is not clear, however, is what circumstances might constitute disturbance elsewhere, such as in pelagic foraging areas. Vessel traffic, nets moving through the water column, or underwater sound production may all represent perturbations, which could affect foraging behavior, but few data exist to determine their relevance to Steller sea lions. The influence of trawl activities on Steller sea lion foraging success cannot be addressed directly with existing data. Foraging could potentially be affected not only by interactions between vessels and sea lions, but also as a function of changes in fish schooling behavior, distributions or densities in response to harvesting activities. In other words, disturbance to the prey base may be as relevant a consideration as disturbance to the predator itself.

For the purposes of this analysis, it is recognized that some level of prey disturbance may occur as a fisheries effect. The impact on marine mammals who prey on fish schools is a function of both the amount of fishing activity and its concentration in space and time, neither of which may be extreme enough under the status quo to represent population-level concerns. To the extent that the baseline condition imposes limits on fishing activities inside critical habitat, it is assumed some protection from these disturbance effects is currently provided. These protections occur as byproducts of other actions that either reduce fishing effort or create buffer zones to limit impacts on foraging. Also, they occur directly in the case of the 3 nm no entry zones around rookeries. With these measures in place, the baseline is consistent with the underlying goal of reducing disturbance effects. Whether the residual levels of disturbance represent significant effects on Steller sea lions cannot be determined with the data that are currently available.

However, anecdotal evidence suggests that fisheries/disturbance related events are unlikely to be of consequence to the Steller's population as a whole. For instance, vessel traffic and underwater sound production have long been features of the Bering Sea and GOA, at least over much of the twentieth century. Such circumstances have prevailed before, as well as after the decline of Steller sea lions, suggesting no obvious causal link. Steller sea lions also appear to be tolerant of at least some anthropogenic effects, recognizing their attraction to fish processing facilities and gillnets as well as their distributions in proximity to ports. Further, the eastern population of Steller sea lions is increasing, despite anthropogenic activities

throughout their range on the west coast of North America and particularly in southeast Alaska. Levels of disturbance to Steller sea lions similar to those occurred in 2002 are expected under FMP 1. The effects of disturbance on Steller sea lions under FMP 1 are expected to be insignificant relative to the baseline.

Cumulative Effects

The past/present effects on the Steller sea lion are described in Section 3.8.1 (Table 3.8-1) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. This analysis seeks to provide an overall assessment of the species' population-level response to its environment as it is influenced by the groundfish fishery. The effects considered in this analysis are listed in Table 4.5-62. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Mortalities from incidental take and entanglement in derelict fishing gear occur at frequencies that do not have population-level effects on the western population of Steller sea lions and are therefore considered insignificant.

- **Persistent Past Effects.** Substantial mortality of Steller sea lions did not occur in the fisheries until after the 1950s. The take of Steller sea lions was substantial after this time with over 20,000 animals believed to have been incidentally killed in the foreign and JV groundfish fisheries from 1966 to 1988, although data from this period are not complete (Perez and Loughlin 1991). In the BSAI groundfish trawl fisheries, incidental take has declined from about 20 per year in the early 1990s to an average of 7.8 sea lions per year from 1996 to 2000. The number of Steller sea lions incidentally taken in state-managed nearshore salmon gillnet fisheries and halibut longline fisheries is estimated at 14.5 sea lions per year in the PWS drift gillnet fisheries (Wynne *et al.* 1992). It is thought that shooting used to be a significant source of mortality prior to listing the Steller sea lion as endangered under the ESA. Two cases of illegal shooting were prosecuted in the Kodiak area in 1998 involving two Steller sea lions from the western population (Angliss *et al.* 2001). The subsistence harvest of the western population has decreased over the last ten years from 547 to 171 animals per year (1992 to1998) (Angliss and Lodge 2002). Commercial harvest of sea lions for hides and meat occurred prior to 1900 and likely depleted some local populations. Over a nine year period, 1963 to 1972, more than 45,000 Steller sea lion pups were taken for commercial purposes (Merrick *et al.* 1987). Predation by transient killer whales and sharks has always contributed to the natural mortality of Steller sea lions. The numbers of sea lions taken and the relative contribution of this factor to the recent population decline and lack of recovery is currently under investigation (Matkin *et al.* 2001, Matkin *et al.* 2003, Springer *et al.* 2003).

- **Reasonably Foreseeable Future External Effects.** Incidental take in the state-managed fisheries such as salmon gillnet fisheries will continue in the foreseeable future but the numbers of Steller sea lions will likely be relatively low (fewer than 10 per year). Entanglement in fishing gear and intentional shootings would also be expected to continue at a level similar to the baseline condition. Predation will continue to contribute to natural mortality but climate change and regime shifts would not be expected to have direct effects on mortality of Steller sea lions.

- **Cumulative Effects.** The cumulative effect of mortality based on the contribution of internal effects of the groundfish fishery and external mortality factors is considered significantly adverse for the western population of Steller sea lions. The western population of Steller sea lions has declined approximately 80 percent since the 1970s and was listed as endangered under the ESA in 1997. A number of human-caused mortality factors have been identified as potentially contributing to this decline and lack of recovery. According to current estimates, incidental take from the BSAI and GOA groundfish fisheries and other fisheries (29) and subsistence harvest (198) exceeds the PBR (208) for the western population of Steller sea lions (Angliss and Lodge 2002). In addition, natural mortality factors, such as predation by transient killer whales and sharks, may be relatively more important for a depressed population and may be inhibiting the recovery of the Steller sea lion population. Because the population is still depressed from historic levels, has not recovered to the point that a recovery rate can be reliably calculated, and overall human-caused mortality exceeds the PBR for this population, the cumulative effect of all mortality factors is considered significantly adverse for the western population of Steller sea lions. The contribution of the groundfish fisheries to mortality is small compared to total human-caused mortality, and as such, has been determined not to jeopardize the continued existence or recovery of the western population under the ESA (NMFS 2001b).

Prey Availability

- **Direct/Indirect Effects.** The combined harvest of Steller sea lion prey species under FMP 1 is not expected to result in population-level effects and is rated as insignificant.

- **Persistent Past Effects.** Past effects on key prey species of Steller sea lions include harvest of species that were targeted or taken as bycatch by the foreign, JV, and domestic groundfish fisheries and parallel fisheries in state waters, and partial overlap with other state-managed fisheries. There is substantial evidence that nutritional stress played an important role in the rapid decline of the western population of Steller sea lions during the late 1970s and 1980s. One hypothesis is that the combined fisheries, perhaps in conjunction with climate and oceanographic fluctuations, greatly reduced the availability of forage fish to Steller sea lions. NMFS issued a number of Biological Opinions (BiOps) since 1991 that analyzed the key issue of whether the groundfish fisheries were contributing to the decline of the western population of Steller sea lions or causing adverse impacts to their critical habitat. A recent Steller sea lion BiOp and EIS (NMFS 2001b and 2001c) explores this subject in great depth.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon and herring are expected to continue in future years in a generally similar manner to the baseline conditions. New fisheries in state or federal waters are not anticipated. Climate change or regime shifts were identified as potentially having adverse effects of availability of prey but the direction or magnitude of these changes are difficult to predict. Climate induced change has been suspected in the decline of the western stock Steller sea lion.

- **Cumulative Effects.** The cumulative effect on prey availability for Steller sea lions is based on direct, indirect, and external effects on prey and is considered conditionally significant adverse. This rating is based on the adverse effects on prey availability in the past from foreign, JV, and domestic groundfish fisheries, the state-managed salmon and herring fisheries, and indications that prey availability has been a key factor in the decline of the western population over the last several

decades. This rating is conditional based on the uncertainty of whether future harvests from all fisheries will combine with natural fluctuations to affect prey availability such that the western population of the Steller sea lion continues to decline or is delayed in its recovery.

Spatial/Temporal Concentration of Fisheries

- **Direct/Indirect Effects.** Spatial and temporal fishing measures in FMP 1 do not deviate from the baseline; thus, the effects of the spatial/temporal concentration of the fisheries under FMP 1 are determined to be insignificant to Steller sea lions.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries, as well as state-managed fisheries for salmon and herring have all attempted to maximize their catch per unit effort by concentrating their fishing at times and places where fish are most concentrated. There is substantial evidence that nutritional stress played an important role in the rapid decline of the western population of Steller sea lions during the late 1970s and 1980s, and one hypothesis is that the combined fisheries caused localized depletion of forage fish. Past changes in the domestic groundfish harvest regulations have dispersed the fishing effort in time and space in order to minimize the potential for localized depletion of Steller sea lion prey. Minimizing the competitive overlap between the fisheries and Steller sea lions is the primary focus of sea lion protective measures, which constitute the baseline condition.

- **Reasonably Foreseeable Future External Effects.** The only reasonably foreseeable future factors external to the groundfish fisheries that affect the spatial/temporal harvest of Steller sea lion prey would be the state-managed salmon and herring fisheries, which remove Steller sea lion prey during the spring and summer months. These fisheries are expected to continue to be managed as they have been in recent years. No new state or federal fisheries are anticipated at this time.

- **Cumulative Effects.** The cumulative effect of the spatial/temporal harvest of prey is based on past and future effects of the groundfish fisheries and state-managed fisheries and is considered conditionally significant adverse. Although there are several hypotheses regarding the decline and lack of recovery of Steller sea lions, localized depletion of prey due to commercial fishing is a plausible mechanism for population-level effects. This rating is conditional based on the uncertainty of whether future harvests from all fisheries will combine to cause localized depletion of prey in key areas such that the western population of the Steller sea lion continues to decline or is delayed in its recovery.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance on Steller sea lions under FMP 1 are considered to be insignificant.

- **Persistent Past Effects.** Past effects of disturbance were identified from foreign, JV, and domestic groundfish fisheries in the BSAI and GOA and state-managed fisheries. Past disturbances were also identified from commercial harvest, intentional shooting and subsistence harvest. General vessel traffic and disturbance to prey fields from fishing gear have also regularly occurred in the past.

- **Reasonably Foreseeable Future External Effects.** Future sources of disturbance were identified for state-managed salmon and herring fisheries as well as general fishing and non-fishing vessel traffic in Steller Sea lion foraging areas. Subsistence harvest was also identified as a continuing source of low level disturbance to Steller sea lions. The level of disturbance is expected to be similar to baseline conditions.

- **Cumulative Effects.** The cumulative effect of disturbance to Steller sea lions is based on contributions from both internal and external events. This effect is considered insignificant, because the level of disturbance is similar to the baseline condition and population-level effects are unlikely.

4.5.8.2 Eastern Distinct Population Segment of Steller Sea Lions

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

With regard to incidental take, FMP 1 is not likely to result in significant changes to the population trajectory of the eastern distinct population segment (eastern population) of Steller sea lions. No Steller sea lions from the eastern population have been taken incidental to groundfish fisheries from 1995 to 1999 (Angliss *et al.* 2001) (Table 4.5-60). In this context, incidental take refers to animals that are either killed or sustain injuries that are expected to result in death. Because no animals from the eastern population have been taken incidental to groundfish fisheries, changes in catch resulting from the FMP 1 are not expected to result in an increase in the level of incidental takes.

Entanglement of Steller sea lions from the eastern population in derelict fishing gear or other marine debris seems to occur at frequencies that do not have significant effects upon the population. Entanglement of sea lions in derelict fishing gear or other marine debris does not appear to represent a significant threat to the population. In conclusion, incidental take and entanglement in marine debris under the FMP 1 are insignificant according to the criteria set for significance (Table 4.1-6).

Fisheries Harvest of Prey Species

BSAI groundfish fisheries are not likely to have large impacts on the prey availability of the eastern population of Steller sea lions as there is little overlap with this population and fisheries that harvest Steller sea lion prey species. Only fisheries in the GOA would be expected to have an effect on the eastern population of Steller sea lions. Average fishing mortality rates of GOA pollock and Pacific cod are expected to increase by one percent and decrease by 17 percent, respectively, relative to the comparative baseline over the next 5 years under FMP 1. The changes in the fishing mortality rates expected to occur under FMP 1 are insignificant at the population level for Steller sea lions.

Little difference is expected relative to the baseline for harvest of other, non-target species that are prey for Steller sea lions (e.g. cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMPs were determined to be insignificant to Steller sea lions. The combined harvest of prey species for the eastern population of Steller sea lions under FMP 1 is not expected to result in population-level effects and was determined to be insignificant overall.

Spatial/Temporal Concentration of the Fishery

The criterion used to evaluate the spatial/temporal effects of the groundfish fisheries on marine mammal populations is that the alternative FMP would be expected to result in either increased or decreased spatial/temporal concentrations in key marine mammal foraging areas and periods such that prey resources are altered to the extent that population-level effects would be expected to occur. The spatial/temporal measures in FMP 1 (and retained throughout all of the alternative FMPs) were designed with the objective of reducing competitive interactions between groundfish fisheries and Steller sea lions in their key foraging areas during periods that are believed to be critical to Steller sea lions. Opportunistic sightings of Steller sea lions (sightings reported ancillary to other activities, e.g., surveys for other species, fishing, or shipping) indicate that Steller sea lions occur in offshore areas where protective measures designed to reduce fishing and sea lion interactions have not been instituted (POP 1997). The potential for competitive interaction between groundfish fisheries and Steller sea lions exists in areas that are not managed with seasonal or spatial fishery closures yet where sea lions are known to occur. Under the baseline conditions, such potential interactions are thought to be reduced by overall groundfish harvest limits, also referred to as "global controls." Additionally, groundfish fisheries have been dispersed in time and space under the baseline conditions, such that the competitive interactions with Steller sea lions are thought to be mitigated to a level that is not expected to appreciably reduce the likelihood of survival and recovery of the eastern population of Steller sea lions in the wild. Spatial and temporal fishing measures in FMP 1 do not deviate from the baseline; thus, the effects of the spatial/temporal concentration of the fisheries under the FMP 1 are determined to be insignificant to the eastern population of Steller sea lions according to the criteria established in Table 4.1-6.

Disturbance

Levels of disturbance similar to those that occurred to the eastern population of Steller sea lions in 2002 are expected under the FMP 1 management regime. Therefore, according to the significance criteria established in Table 4.1-6, the effects of disturbance on the eastern population of Steller sea lions under the FMP 1 are expected to be insignificant relative to the baseline.

Cumulative Effects

The past/present effects on the eastern population of the Steller sea lion in southeast Alaska are described in Section 3.8.1 (Table 3.8-1) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above. The effects considered in this analysis are listed in Table 4.5-63. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** With regard to incidental take, FMP 1 is expected to have insignificant changes to the population trajectory of the eastern population of Steller sea lions (see Direct and Indirect Effect above).

- **Persistent Past Effects.** It is thought that shooting used to be a significant source of mortality prior to listing the Steller sea lion as threatened under the ESA. NMFS Alaska Enforcement Division has successfully prosecuted two cases involving illegal shooting of four sea lions from the eastern population (Angliss *et al.* 2001). It is not known to what extent illegal shooting continues in the eastern population but stranding of sea lions with bullet holes still occurs. Predator control programs

associated with mariculture facilities in British Columbia account for a mean of 44 animals killed per year from the eastern population (Angliss and Lodge 2002). The subsistence harvest from the eastern population is very small and is subject to an average of only two sea lions taken per year from southeast Alaska (1992-1997) (Angliss and Lodge 2002). Commercial harvest of sea lions for hides and meat occurred prior to 1900 and likely depleted some local populations. Over a nine-year period, 1963 to 1972, more than 45,000 Steller sea lion pups were taken for commercial purposes (Merrick *et al.* 1987). The proportion of these from the eastern population is unknown. Intentional shooting of Steller sea lions, other than in subsistence hunts, became illegal after the species was listed as threatened under the ESA in 1990. It is thought that shooting was a significant source of mortality prior to that time. Steller sea lions are incidentally taken in low numbers by commercial fisheries other than groundfish fisheries, including some state-managed salmon drift and set gillnet fisheries, and the salmon troll fishery in southeast Alaska (mean of 1.25 and 0.2, respectively) (Angliss and Lodge 2002). Small numbers of sea lions from the eastern population are also taken outside of southeast Alaska in groundfish fisheries (0.45 per year in Washington, Oregon, and California) and set gillnet fisheries in Northern Washington State (0.2 per year) (Angliss and Lodge 2002). The PBR for this population is 1,396 and current human caused mortality is 45.5, substantially less than 10 percent of the PBR.

- **Reasonably Foreseeable Future External Effects.** Incidental take in the state-managed fisheries such as salmon gillnet and troll fisheries will continue in the foreseeable future but the numbers of Steller sea lions will likely be relatively low (<10 per year). Groundfish fisheries in Washington, Oregon, and California and salmon set gillnets fisheries will continue to take small numbers from this population. Entanglement and intentional shootings would also be expected to continue. Pollution is likely more of a factor for this population due to the closer association with human population centers. Climate change and regime shifts would not be expected to have direct effects on mortality of Steller sea lions.

- **Cumulative Effects.** The cumulative effect of mortality based on the contribution of internal effects of the groundfish fishery and external mortality effects is considered insignificant because the overall human-caused mortality does not approach the PBR for this population. Although this population is listed as threatened under the ESA, the population has been increasing over the last 20 years. The contribution of the groundfish fisheries is very small in comparison to the total human-caused mortality and has been determined not to cause jeopardy under the ESA (NMFS 2001b).

Effects of Prey Availability

- **Direct/Indirect Effects.** The combined harvest of the eastern population of Steller sea lion prey species under FMP 1 is not expected to result in population-level effects and is therefore determined to be insignificant.

- **Persistent Past Effects.** Past effects on key prey species of Steller sea lions include harvest of species that are targeted or taken as bycatch by the GOA groundfish fisheries and parallel fisheries in state waters, and partial overlap with other state-managed fisheries. These species were also targeted in the past foreign and JV groundfish fisheries. NMFS issued a number of BiOps since 1991 that analyzed the key issue of whether the groundfish fisheries were contributing to the decline of Steller sea lion populations or causing adverse impacts to their critical habitat but most of the focus

was on the western population. A recent Steller sea lion BiOp and EIS (NMFS 2001b and 2001c) explore this subject in great depth.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon and herring are expected to continue in future years in a generally similar manner to the baseline condition. New fisheries in state or federal waters are not anticipated. Climate change or regime shifts were identified as potentially having adverse effects of availability of prey but the direction or magnitude of these changes are difficult to predict. Climate induced change has been suspected in the decline of the western population Steller sea lion, but effects of climate change or regime shifts on the eastern population of the Steller sea lion are largely unknown.

- **Cumulative Effects.** The cumulative effects of prey availability on the eastern population of the Steller sea lion are considered to be insignificant at the population level. The eastern population of Steller sea lions has been increasing steadily over the last 20 years so prey availability is not considered to be limiting the recovery of the population.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** Spatial and temporal fishing measures in the FMP 1 do not deviate from the baseline; thus, the effects of the spatial/temporal concentration of the fisheries under FMP 1 are determined to be insignificant to the eastern population of Steller sea lions.

- **Persistent Past Effects.** Past effects of spatial/temporal harvest of prey were identified for foreign, JV, federal and domestic groundfish fisheries, and state-managed fisheries for salmon and herring. Past changes in the groundfish harvest have dispersed the fishing effort in time and space in order to minimize effects on Steller sea lions. Minimizing the competitive overlap between the fisheries and Steller sea lions is the primary focus of sea lion protective measures, which remain in effect under FMP 1.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon drift and set gillnet fisheries, salmon troll fisheries, and herring fisheries are expected to continue in future years in a generally similar manner to the baseline conditions.

- **Cumulative Effects.** The cumulative effect of spatial and temporal harvest of prey based on both internal and external sources is considered to be insignificant. This is because the effect is likely to remain similar to the baseline condition, under which the population has steadily increased.

Disturbance

- **Direct/Indirect Effects.** The effects of disturbance on Steller sea lions under the FMP 1 are expected to be similar to the baseline, and population-level effects are unlikely; therefore, internal effects are considered insignificant. Protection measures around rookeries and haulouts that limit the potential for disturbance will continue under FMP 1.

- **Persistent Past Effects.** Past disturbance was identified for foreign, JV, and domestic groundfish fisheries as well as state-managed salmon and herring fisheries. General vessel traffic has also

contributed to the disturbance level for this population. Intentional shooting has likely been a factor in disturbance in past years.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries and vessel traffic will likely continue in the future at a level similar to the baseline condition. Disturbance from subsistence harvest is not an issue for this population.

- **Cumulative Effects.** The cumulative effect of disturbance of prey based on both internal and external sources is considered to be insignificant. This is because the effect is likely to remain similar to the baseline condition, under which the population has increased steadily.

4.5.8.3 Northern Fur Seals

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

With regard to incidental take, the FMP 1 is not likely to result in significant changes to the population trajectory of northern fur seals. The incidental take of northern fur seals is uncommon in the groundfish fisheries. The last recorded mortality in any Alaskan groundfish fishery occurred in 1996, when the take rate was one animal per 1,862,573 mt of groundfish harvested. Observer records from 1990 to 1999 indicate that direct interactions with groundfish vessels occurred only in the BSAI trawl fishery, despite observer placement in pot, longline and trawl fisheries in both the BSAI and GOA. In the BSAI trawl fishery, the average annual take rate (1995 to 1999) was 0.6. Since PBR for this population is 17,138 animals per year (Angliss and Lodge 2002), this level of take is inconsequential to population trends.

Northern fur seal entanglement in marine debris is more common than any other species of marine mammal in Alaskan waters (Laist 1987, 1997, Fowler 1987). Fowler (1987) concluded that mortality of northern fur seals from entanglement in marine debris contributed significantly to declining trends in the Pribilof Islands during mid to late 1970s and early 1980s. The contribution of intentional discard of net debris from Alaskan groundfish fisheries vessels is thought to have declined over the past decade. However, consistent numbers of seals entangled in packing bands on St. Paul Island may reflect disposal of these materials in proximity to the islands. Recent data from satellite-tracked drifters deployed in the Bering Sea suggests a "trapped" circulation pattern around the Pribilof Islands (Stabeno *et al.* 1999) which may retain marine debris in the nearshore environment. An increase in the number of Antarctic fur seals (*Arctocephalus gazella*) entangled in polypropylene packing bands was observed at Bird Island, South Georgia, in the late 1980s as these materials came into common usage by at-sea processing vessels (Croxall *et al.* 1990). Involuntary sources of marine debris, as in loss of gear, are diminishing as fishery cooperative systems develop (such as in the BSAI offshore pollock allocation). That is, as the pace of fisheries is slowed, there is less incentive to risk capital equipment. Data do not yet exist to assess the rates at which various gear types are lost or discarded to result in risk to fur seals, especially in regard to fishery or nation of origin. In consideration of progress in stemming the loss and discard of net fragments and other plastic debris by domestic commercial fisheries, the extent to which the current FMP could change the rate of fur seal entanglement in marine debris is considered to be low. There seem to be few options, given the likelihood that sources beyond the control of fisheries managers (i.e., foreign fisheries, international shipping, and shoreside refuse) constitute significant sources of discard. In view of these factors, the effects on northern fur seals under the FMP 1 are rated insignificant, with respect to incidental take and entanglement in marine debris.

Fisheries Harvest of Prey Species

The diet of northern fur seals includes a wide range of fish species, with less apparent dependence on Pacific cod and Atka mackerel compared to Steller sea lions. However, both adult and juvenile pollock occur in the diet of northern fur seals and consumption rates vary according to the abundance of different age classes of pollock in the foraging environment (Swartzman and Haar 1983; Sinclair *et al.* 1996). Because fur seals are opportunistic foragers, the presence of strong year-classes results in a disproportionately high percentage of that age class of pollock in the fur seal diet. Evaluation of the effects of harvest of prey species on northern fur seals, focuses less on removals of Pacific cod and Atka mackerel and more broadly on removals of pollock and small schooling fishes. Northern fur seals forage at shallow to mid-water depths of 0 to 820 ft (0-250 m), both near shore and in pelagic regions of their migratory range. Female and young male fur seals generally consume both juvenile and adult small-sized (2 to 8 inches) schooling fishes and squids although diet varies across oceanographic subregions along their migration routes and around breeding locations in the Pribilof Islands. In the eastern Bering Sea, primary prey species include pollock and Pacific cod, but deep sea smelts, lanternfish, and squids are also major components. Studies based on scat analysis have indicated that the pollock and Pacific cod consumed by fur seals tend to be smaller than those selected by the target fisheries, however data from stomach collections from the 1960s through the 1980s indicate that fur seals often consume adult pollock. Recent studies using bio-chemical methods to study the diet of northern fur seals suggests that the diet of deep diving fur seals in waters over the continental shelf includes adult pollock (Kurle and Worthy 2000, Goebel 2002).

Under the FMP 1, the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 22 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals the change in the harvest of adult pollock , which is a key prey species of northern fur seals in the EBS, is rated significantly adverse. However, overall harvest of northern fur seal prey species is considered insignificant under the FMP 1 due to the factors explained below.

Catches of squid and small schooling fish (e.g., fish designated in the forage fish assemblage) in the groundfish fisheries of the BSAI and GOA are low, generally less than 1,000 mt per year. While precise biomass estimates for these groups do not exist, the exploitation rate on these groups in the groundfish fisheries is thought to be very low. For instance, squid biomass in the Bering Sea may be as large as 4 million mt, based on marine mammal food habits, daily ration, and abundance data (Sobolevsky 1996). Similarly, with respect to small schooling fishes, consumption of capelin in the GOA by arrowtooth flounder alone may be as large as 300,000 mt per year (Livingston 1994). Assuming that these crude projections of squid and capelin biomass at least approximate the order of magnitude of the true population levels, then the fisheries removals would amount to only a fraction of one percent of those populations. Fisheries for pollock and Pacific cod do not target fish younger than 3 years of age (Ianelli *et al.* 1999, Dorn *et al.* 1999, Thompson and Dorn 1999, Thompson and Zenger 1994, Fritz 1996). Catches of pollock smaller than 30 centimeters (cm) are small, and thought to be only 1 to 4 percent of the number of one- and two-year olds each year in the EBS and GOA (Fritz 1996).

Therefore, while fisheries do harvest prey of northern fur seals (i.e. pollock and Pacific cod), competition due to the harvest rates of those species may vary depending on the size range consumed by northern fur seals. The overall catch of juvenile pollock has tended to be low in recent years and the degree to which adult pollock occur in the northern fur seal diet is not certain. While the potential overlap with fisheries may be moderated by these factors, effects on northern fur seals may yet exist, the relevance of which is not reflected by estimates of biomass removals over large geographical areas.

The potential for competitive overlap between northern fur seals and groundfish fisheries may be tempered by the spatial and temporal distribution of the harvest. These effects are analyzed under the "Spatial/Temporal" heading. Fisheries may also trigger trophic level effects which may affect the availability of northern fur seal prey and these effects are discussed in the ecosystem section.

Spatial/Temporal Concentration of the Fishery

Spatial and temporal fishing measures in the FMP 1 do not deviate from the baseline, thus the effects of the spatial/temporal concentration of the fisheries under the FMP 1 are determined to be insignificant to northern fur seals according to the criteria established in Table 4.1-6. However, effects to northern fur seals from spatial/temporal concentration of the fisheries under the strategy defined as the baseline for this environmental analysis were rated conditionally significant adverse in the Steller sea lion SEIS (NMFS 2001b). Therefore, while changes in the spatial/temporal effects of FMP 1 are insignificant relative to the baseline, the baseline has been described as having potential adverse effects on northern fur seals based on past concentration of the fisheries.

In recent years, fishing effort for pollock has increased in nearshore areas around the Pribilof Islands (NMFS 2003) where northern fur seals are known to forage. The greatest potential for temporal overlap between northern fur seals and the pollock fishery in the eastern Bering sea is July through November. Under the baseline, pollock fisheries were extended in order to slow the pace of the fishery and now occur from June through October. This disperses the harvest over a longer time period than in previous seasons, thereby reducing temporal concentration of the fisheries. However, this change also extends the fisheries into the summer months when fur seals are concentrated near the Pribilof Island rookeries and may thus increase the likelihood of localized effects in foraging areas near the Pribilofs (NMFS 2001b). Seasonally, the highest bycatch of small pollock occurs during the summer (May-July) when spawning aggregations have dispersed and pollock are generally less segregated by size (Fritz 1996). However, given the expected temporal dispersal of the fisheries under FMP 1 and the steadily increasing biomass trends for pollock, the magnitude of harvest and bycatch of species/size classes important to fur seals during the breeding season is not expected to cause localized depletion of prey to the point that the fur seal population as a whole will be affected. Therefore, the spatial/temporal concentration of the fishery under FMP 1 is determined to be insignificant to northern fur seals.

Disturbance

Disturbance from the baseline level of fishing activities has not been implicated as a potential cause for the population decline of northern fur seals. FMP 1 is expected to produce similar levels of disturbance as the baseline which are unlikely to have population-level effects and are therefore considered insignificant according to the significance criteria established in Table 4.1-6.

Cumulative Effects

A summary of the past/present effects on the northern fur seal are described in Section 3.8.2 (Table 3.8-2), and the predicted direct and indirect effects of the groundfish fishery under FMP1 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. This analysis seeks to provide an overall assessment of the species' population-level response to its environment as it is influenced by the groundfish fishery. The effects considered in this analysis are listed in Table 4.5-64. Representative direct effects used in this analysis include mortality and

disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** With respect to mortality and entanglement in marine debris, the effects on the northern fur seal under the FMP 1are rated as insignificant.

- **Persistent Past Effects.** Effects of past mortality on fur seal population include commercial harvest of young males up to 1985, harvest of females between 1956 and 1968, incidental take in the JV fisheries, foreign fisheries, and annual subsistence harvest on the Pribilof Islands. Commercial harvest of fur seals peaked in 1961 with over 126,000 animals but was halted in 1985. The harvest of female fur seal on the Pribilof Islands, as many as 300,000 between 1956 and 1968, likely contributed to the decline of the population in the late 1970s and early 1980s (York and Kozloff 1987). This precipitous decline resulted in its depleted status under the MMPA. Entanglements may have contributed significantly to declining trends of the population during the late 1970's (Fowler 1987). Since the cessation of commercial harvest in 1985, fur seal number have steadily declined (NMFS 1993, Angliss and Lodge 2002). The contribution of the earlier harvest of fur seal to the subsequent declines is uncertain since it has been nearly 20 years since commercial harvest was ended. Subsistence harvests have been one of the major contributors to fur seal mortality in recent years. From 1986 to 1996, the average annual subsistence take was 1,605 from St. Paul and St. George Islands. From 1995 to 2000 this average take dropped to 1,340 seals per year, which represents about 8 percent of the PBR for this species.

- **Reasonably Foreseeable Future External Effects.** These effects include incidental take from foreign fisheries outside the U.S. EEZ where fur seal are widely dispersed. State-managed fisheries take small numbers of fur seal including PWS drift gillnet fishery, Alaska Peninsula and Aleutian Island salmon gillnet fisheries, and the Bristol Bay salmon fisheries (Angliss and Lodge 2002). Subsistence will continue to be a major source of mortality in the future but is limited to the Pribilof Islands. Levels of take are expected to be well below 10 percent of the PBR for this species. Short-term and long-term climate change is not considered a major mortality factor for this species.

- **Cumulative Effects.** The cumulative effect of mortality from internal and external factors is considered insignificant. The contribution of the groundfish fisheries is very small and approaches zero. The cumulative effect is considered insignificant because of the size of the fur seal population in relation to existing levels of take, which are well below the PBR of this species; therefore, population-level effects are not anticipated.

Availability of Prey

- **Direct/Indirect Effects.** The effect of the groundfish fisheries under the FMP 1 is not expected to have population-level effects, therefore, is rated as insignificant to northern fur seal (see Direct and Indirect Effect above.

- **Persistent Past Effects.** Effect of groundfish harvest in the past has likely occurred from overlap of prey species and fish targeted by the foreign and JV fisheries in the BSAI as well as by the state

and federal fisheries. Climate and oceanic fluctuations are also suspected in past changes in the abundance and distribution of prey.

- **Reasonably Foreseeable Future External Effects.** Effect on prey availability for northern fur seal in the futures is considered to come from a small overlap in prey species with the state-managed salmon and herring fisheries in nearshore areas and effect of climate change/regime shifts on prey species abundance and distribution. Climate effects are largely unknown but could potentially have adverse effects on the availability of prey.

- **Cumulative Effects.** The cumulative effect of prey availability from both the internal contribution of the groundfish fisheries and external effects on prey such as other fisheries and possibly long-term climate change is considered conditionally significant adverse. This rating is based on the fact that the population declined substantially in the past for unknown reasons and that decreased prey availability is a plausible mechanism that could have contributed to the decline. Since the causal link between the population decline and the cumulative effects of all past fisheries on prey availability has not been established, the potentially adverse cumulative effects on northern fur seal through this mechanism are considered conditional.

Spatial/Temporal Concentration of Harvest

- **Direct/Indirect Effects.** The effects of groundfish fisheries under FMP 1 on the spatial/temporal concentration of fisheries harvest are very similar to the baseline conditions; thus, the effects of the spatial/temporal concentration under FMP 1 are determined to be insignificant to northern fur seals.

- **Persistent Past Effect.** Effect of past fisheries harvest of prey are primarily from the foreign and JV fisheries and the state and domestic fisheries in the BSAI. There has been concern with regard to displaced/increased fishing effort that is encroaching into nearshore areas of the Pribilofs resulting in increased overlap with fur seal foraging areas. The proportion of the total June-October pollock catch in fur seal foraging habitat increased from an average of 40 percent in 1995-1998 to 69 percent in 1999-2000 (NMFS 2001b). There is particular concern that this increased fishing pressure could have impacted lactating females from St. George Island where catch rates were consistently higher than in areas used by females from St. Paul (Robson *et al.* 2004).

- **Reasonably Foreseeable Future External Effects.** Effects of the spatial/temporal harvest of prey species are primarily from the foreign and domestic fisheries outside the EEZ, due to the extensive range of the fur seal when they are away from their breeding rookeries. state-managed fisheries have very limited overlap with fur seal prey. Climate change was also identified as a potential factor in spatial/temporal effects on prey.

- **Cumulative Effects.** The cumulative effect of the spatial/temporal harvest of prey based on the presence of internal and external factors is considered conditionally significant adverse. This rating is based on the fact that the population declined substantially in the past for unknown reasons and that localized depletion of prey is a plausible mechanism that could have contributed to the decline. The potentially adverse cumulative effects on northern fur seal through this mechanism are considered conditional because the causal link between the population decline and the cumulative effects of all past fisheries on localized depletion of prey has not been established.

Disturbance

- **Direct/Indirect Effects.** FMP 1 is expected to produce similar levels of disturbance as the baseline, and as such, these effects are unlikely to have population-level effects and are therefore considered insignificant at the population level.

- **Persistent Past Effects.** Past disturbance of fur seals includes commercial groundfish fisheries harvest by foreign, JV, and domestic groundfish fisheries, state-managed fisheries, and, to a lesser extent, the subsistence harvest of fur seal on the Pribilof Islands. It is unlikely that disturbance persists as a result of these past activities but the ongoing fisheries do continue to result in some level of disturbance to fur seal while they are in the BSAI region.

- **Reasonably Foreseeable Future External Effects.** Future external disturbance effects on fur seal were identified for state-managed fisheries and subsistence activities on the Pribilof Islands. No new fisheries are expected within the range of the northern fur seal.

- **Cumulative Effects.** The cumulative effect of disturbance from internal and external factors is considered insignificant because there is little evidence to indicate an adverse effect at the population level for this degree of disturbance.

4.5.8.4 Harbor Seals

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

In both the GOA and BSAI, groundfish fisheries takes of harbor seals are at levels approaching zero and are insignificant factors in population trends. Reported cases of harbor seal entanglement in marine debris are less prevalent than for northern fur seals or Steller sea lions (Laist 1987, 1997). Given their inshore distribution and the high frequency with which they are observed, the low incidence of entanglement is unlikely to be a result of few opportunities to document such events. Thus, the effect of direct take and entanglement in marine debris under FMP 1 on harbor seal populations is rated insignificant.

Fisheries Harvest of Prey Species

The major prey of harbor seals in Alaskan waters include fish from the following families: Gadidae, Clupeidae, Cottidae, Pleuronectidae, Salmonidae, Osmeridae, Hexagrammidae, and Trichodontidae. Octopus and gonatid squid are also important. However, overlaps with commercial groundfish fisheries occur primarily with reference to pollock, Atka mackerel, and Pacific cod, which may constitute grounds for indirect interactions, particularly in the GOA and Aleutian Islands. However, the basis for concern is less pronounced than those noted for Steller sea lions, or even for northern fur seals, so that the overall effects are likely to be lower as well. Pollock, Atka mackerel, and Pacific cod constitute approximately 12, 9, and 8 percent, respectively, of harbor seal diet in the Aleutian Islands and Bering Sea (Perez 1990). In the GOA, pollock, octopus and capelin were reported by Pitcher and Calkins (1979) as the most important prey, while Pacific cod was less important and Atka mackerel were absent in the sample. Ashwell-Erickson and Elsner (1981) estimated that harbor seals and spotted seals combined consume approximately 81,600 mt of pollock per year, compared to current Bering Sea pollock biomass estimates (1998) of over 9 million mt. Pollock

removals by fisheries are less than 10 percent of the biomass estimate, suggesting that in terms of volume, the unharvested fraction is sufficient to satisfy harbor seal foraging needs. Under FMP 1, the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 22 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals the change in the harvest of this key harbor seal prey species is rated significantly adverse. See the discussion regarding the aberrant fishing mortality rate for EBS pollock in 2002 (which served as the comparative baseline) in Section 4.5.9.1.

The fishing mortality rate of GOA pollock is expected to increase by an average of one percent relative to the comparative baseline over the next 5 years under the FMP 1. This change in F is insignificant at the population level for harbor seals. Under the FMP 1, the BSAI Pacific cod fishing mortality rates is expected to increase by 20 percent which was determined to be insignificant to harbor seals according to the criteria established in Table 4.1-6. Changes in Aleutian Islands Atka mackerel harvest are expected to be significantly adverse to harbor seals with a 60 percent increase in F relative to the baseline.

Little difference is expected relative to the baseline and among the alternatives for harvest of other, non-target species that are prey for harbor seals (e.g. cephlapods and forage fish such as capelin). Changes in the harvest of these species under FMP 1 was determined to be insignificant to harbor seals. Although there is overlap in species/size classes taken by the groundfish fisheries and harbor seal prey, harbor seals also consume a large amount of other prey species. The combined harvest of harbor seal prey species under FMP 1 is not expected to increase substantially from the baseline condition or to result in population-level effects and was determined to be insignificant overall.

Spatial/Temporal Concentration of the Fishery

Spatial and temporal fishing measures in FMP 1 do not deviate from the baseline; thus, the effects of the spatial/temporal concentration of the fisheries under the FMP 1 are determined to be insignificant to harbor seals according to the criteria established in Table 4.1-6.

Disturbance

The potential for disturbance effects caused by vessel traffic, fishing gear, or noise appears limited for harbor seals. These animals are common in nearshore waters and are subjected to considerable levels of anthropogenic disturbances, typical of ports and shipping lanes. Interactions with groundfish fishing gear, such as trawl nets, also appears limited, based on the rare incidence of takes in groundfish fisheries. Finally, given the nearshore distribution of harbor seals, their overlap with fishing activities is more limited than in the case of either Steller sea lion or northern fur seals. FMP 1 is expected to produce similar levels of disturbance as the baseline which are unlikely to have population-level effects and are therefore considered insignificant according to the significance criteria established in Table 4.1-6.

Cumulative Effects

A summary of the past and present effects with regards to harbor seals is presented in Section 3.8.4. (Table 3.8-4). The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case (Table 4.5-65). Representative direct effects used in this analysis include

mortality and disturbance. Indirect effects include availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** In both the GOA and BSAI, groundfish fisheries' takes of harbor seals are at levels approaching zero and do not likely affect population trends. Thus, the effect of incidental take and entanglement in marine debris under FMP 1 is rated as insignificant at the population level.

- **Persistent Past Effects.** Residual effect on local populations of state predator control programs (1950s to 1972) and commercial hunts (1963 to 1972) may still occur in some areas although there is no data on these factors. Foreign and JV groundfish fisheries in the 1960s and 1970s have likely contributed to some level of direct harbor seal mortality from entanglement in gear but based on the near shore distribution of harbor seals, there was likely minimal direct interaction and mortality is believed to have been very low. From 1990 to 1996, minimum estimates of harbor seals taken incidentally in groundfish gear in the Bering Sea were 4 per year and less than 1 per year in the GOA. In southeast Alaska, 4 harbor seals are estimated to be killed each year on longlines. Harvest of harbor seals for subsistence purposes is likely the highest cause of anthropogenic mortality for this species since the cessation of commercial harvests in the early 1970s. Between 1992 and 1998, the state-wide harvest of harbor seals from all stocks ranged between 2,546 and 2,854 animals, the majority of which are taken in southeast Alaska (Wolfe and Hutchinson-Scarbrough 1999). Harvest of Bering Sea stock of harbor seals is approximately 161 animals, 42 percent of PBR for this species. For the GOA stock, the harvest is at approximately 91 percent of the PBR for this stock. For the southeast stock, harvest is at approximately 83 percent of PBR.

- **Reasonably Foreseeable Future External Effects.** Incidental take of harbor seals in state-managed fisheries such as salmon set and drift gillnet fisheries would be expected to continue at its present low rate. Subsistence take is expected to continue to be the greatest source of human-controlled mortality with a relatively high percentage of the PBR in both the GOA and southeast Alaska stock and a lower take in the BSAI region. Climate change is likely not a factor in the direct mortality of harbor seals although there would likely be indirect effects.

- **Cumulative Effects.** The cumulative effect of mortality from both the internal contribution of the groundfish fisheries and external factors is considered insignificant. The human-caused mortality for all harbor seals is below the PBR for each stock and, therefore, population-level effects are unlikely.

Availability of Prey

- **Direct/Indirect Effects.** The combined harvest of harbor seal prey species under FMP1 is not expected to result in population-level effects and was determined to be insignificant overall.

- **Persistent Past Effects.** Availability of prey for harbor seals in the past has likely been affected by foreign, JV, and domestic groundfish fisheries, and state-managed salmon and herring fisheries since the fish targeted by these fisheries are also prey of the harbor seal. Climate change/regime shift could possibly have been a factor in fluctuations in prey availability in the past.

- **Reasonably Foreseeable Future External Effects.** state-managed salmon and herring fisheries are identified as potential adverse effects on harbor seal prey availability, especially in preferred nearshore foraging areas. Climate change/regime shift will continue to be a contributing factor although the effects can be either beneficial or adverse, depending on direction and magnitude of the change.

- **Cumulative Effects.** The cumulative effect of prey availability from internal effects of the groundfish fisheries and external factors is considered conditionally significant adverse. This rating is based on the fact that the population has declined substantially in the past for unknown reasons and that decreased prey availability is a plausible mechanism that could have contributed to the decline. Since the causal link between the population decline and the cumulative effects of all past fisheries on prey availability has not been established, the potentially adverse cumulative effects on harbor seals through this mechanism are considered conditional.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** Spatial and temporal fishing measures in FMP 1 do not deviate from the baseline, thus the effects of the spatial/temporal concentration of the fisheries under the FMP 1 are determined to be insignificant to harbor seals.

- **Persistent Past Effects.** Effects of prey harvest in the past has likely occurred from overlap of harbor seal prey species and fish targeted and areas fished by the foreign and JV fisheries in the BSAI, as well as the state and federal fisheries. Climate and oceanic fluctuations are not considered factors in past changes in the spatial/temporal harvest of harbor seal prey.

- **Reasonably Foreseeable Future External Effects.** Future effects on spatial/temporal harvest is considered for the state-managed fisheries in nearshore areas such as salmon and herring. Since these fisheries generally occur in the nearshore areas in comparison to groundfish fisheries, overlap is more pronounced than with the groundfish fisheries. Effects of climate change/regime shifts on prey species abundance and distribution are also likely in the foreseeable future.

- **Cumulative Effects.** The cumulative effect of the spatial/temporal harvest of prey from internal effects of the groundfish fisheries and external effects of other fisheries is considered to be conditionally significant adverse. This rating is based on the fact that the population has declined substantially in the past for unknown reasons and that localized depletion of prey is a plausible mechanism that could have contributed to the decline. The potentially adverse cumulative effects on harbor seals through this mechanism are considered conditional because the causal link between the population decline and the cumulative effects of all past fisheries on localized depletion of prey has not been established.

Disturbance

- **Direct/Indirect Effects.** Levels of disturbance similar to those that occurred to harbor seals under the baseline conditions are expected under the FMP 1. The effects of disturbance on harbor seals are considered to be insignificant at the population level.

- **Persistent Past Effects.** Disturbance of harbor seals in the past include commercial groundfish fisheries harvest by foreign, JV, and domestic fisheries, commercial harvest, state predator control programs, and to a lesser extent the subsistence harvest of harbor seals. It is unknown whether these past activities have persistent effects in the present but the ongoing fisheries activities and subsistence continue to result in some level of disturbance to harbor seals.

- **Reasonably Foreseeable Future Effects.** State-managed fisheries, general vessel traffic, and subsistence activities would be expected to continue to create some level of disturbance to harbor seals in the foreseeable future.

- **Cumulative Effects.** The cumulative effect of disturbance from internal and external sources is considered to be insignificant. Harbor seals have been exposed to similar levels of disturbance for many years and there is little to indicate an adverse effect of this level of disturbance on the population-level.

4.5.8.5 Other Pinnipeds

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

The incidental take rates in commercial fisheries for ice seals, walrus and northern elephant seals are very low. Mean annual mortality of all ice seals combined from 1995 - 1999 was estimated to be 1.8 animals based on NMFS observers on board BSAI groundfish trawl, longline, and pot fishing vessels (Angliss *et al.* 2001) (Table 4.5-60). These rates constitute levels approaching zero according to NMFS standards (Angliss *et al.* 2001) and are not expected to affect the population trajectories of the species included in this category. The take rate of walrus and elephant seal qualifies as an insignificant level, approaching zero by NMFS standards (Forney *et al.* 2000) and is not expected to affect population trajectory of these species. Entanglement in marine debris is likewise rare for these species and is considered to have insignificant effects. Of the federally-managed fisheries in Alaska, only the EBS and Aleutian Islands pollock fishery would be likely to have an impact on ice seals and walrus, because of their northern distribution in the Bering Sea. Because of their distribution in the GOA and south of the Aleutian Islands (Stewart and DeLong 1994, LeBoeuf *et al.* 2000), northern elephant seals would be likely to be affected only by the GOA and Aleutian Islands pollock and cod fisheries. Population-level effects are not expected to result from incidental take and entanglement under FMP 1. Therefore, incidental take and entanglement of other pinnipeds under FMP 1 is rated insignificant.

Fisheries Harvest of Prey Species

With the exception of spotted seals, the food habits of the ice seals do not overlap with commercial fisheries targets. Bearded seals consume primarily benthic prey including crabs and clams as well as shrimps and Arctic cod (Kosygin 1966, 1971, Lowry 1981a, 1981b). Ringed seals eat Arctic cod, saffron cod, smelt, herring, shrimps, amphipods and euphausiids (Fedoseev 1984, Johnson *et al.* 1966, Lowry *et al.* 1980, McLaren 1958). Ribbon seal diet has been characterized as intermediate between ringed and bearded seals (Shustov 1965). Spotted seals include pollock in their diet when feeding in the central Bering Sea (Bukhtiyarov *et al.* 1984), but their use of that resource in the EBS and Aleutian Islands is unknown. Spotted seal diet in Bristol Bay, the Priblof Islands and the eastern Aleutian Islands is likewise unknown, but if

similar to harbor seals in those areas, it is likely to be diverse and may include a small percentage of commercially important species. Thus, no effects on ice seals are assumed to occur under the baseline, nor are they likely to occur under FMP 1.

With regard to Pacific walrus, their diet is composed almost exclusively of benthic invertebrates (97 percent), particularly bivalve molluscs. Fish ingestion has been considered incidental to their normal feeding behavior (Fay and Stoker 1982). Groundfish removals under FMP 1 would have insignificant effects on walrus populations.

The diet of northern elephant seals in the GOA is unknown, however, the species is known to be a deep diver. This behavior suggests that their foraging may be partitioned by depth from most groundfish fishing activities. The effects of groundfish harvests on prey species for northern elephant seals is determined to be unknown under FMP 1.

Spatial/Temporal Concentration of the Fishery

Spatial and temporal fishing measures in the FMP 1 do not deviate from the baseline, thus the effects of the spatial/temporal concentration of the fisheries under the FMP 1 are determined to be insignificant to other pinnipeds according to the criteria established in Table 4.1-6.

Disturbance

Levels of disturbance similar to those that occurred to other pinnipeds under the baseline are expected under the FMP 1 management regime. Therefore, according to the significance criteria established in Table 4.1-6, the effects of disturbance on other pinnipeds under FMP 1 are expected to be insignificant relative to the baseline.

Cumulative Effects

A summary of the past/present effects on other pinnipeds is presented in Section 3.8.2 and Section 3.8.5 to Section 3.8.9. (Tables 3.8-3 through 3.8-9). The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above. Cumulative effects are summarized in Table 4.5-66.

Mortality

- **Direct/Indirect Effects.** Population-level effects are not expected to result from incidental take and entanglement under FMP 1 and are rated as insignificant.

- **Persistent Past Effects.** Past external effects on the populations of pinnipeds include low levels of incidental take in the foreign, JV, and domestic groundfish fisheries, and low levels of take in the state-managed fisheries. Spotted seal incidental mortality in groundfish fisheries is one per year between 1995 and 1999 (Angliss and Lodge 2002). For bearded seal, the BSAI groundfish fisheries take an average of 0.6 per year. The Bristol Bay salmon drift gillnet fishery from 1990-1993 reported 14 mortalities and 31 injuries of bearded seal. No mortalities of ringed seal have been observed in the last ten years in the BSAI groundfish (Angliss *et al.* 2001). For ribbon seal incidental take, the Bering Sea trawl fishery with one reported taken in 1990, one in 1991, and one in 1997. An average of 86 elephant seals are taken each year in various gillnet fisheries from California to Washington.

Incidental take included one in the Bering Sea trawl fishery in 1990, two in the GOA trawl fishery in 1990, and three in the GOA longline fishery in 1990. One juvenile elephant seal, originally misidentified as a bearded seal, was taken in the Bering Sea trawl fishery in 1991 (Angliss *et al.* 2001). Of the 17 Pacific walrus that were caught each year in groundfish trawl fisheries in the eastern Bering Sea between 1990 and 1997, over 80 percent were already decomposed (Gorbics *et al.* 1998). Subsistence is the major human-caused external factor for mortality. Annual subsistence harvest rates include 5,265 spotted seal, 6,788 bearded seal, 100 ribbon seal, 9,567 ringed seal, 1,000 walrus, and zero elephant seal.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries will likely continue to take very small numbers of seals in this group. Subsistence take of these marine mammals will likely continue at a similar rate to the baseline conditions.

- **Cumulative Effects.** The cumulative effect of mortality within the other pinniped group from both internal effects of the groundfish fisheries and external effects such as subsistence harvest is considered insignificant. For spotted, ringed, bearded, and ribbon seals, PBRs cannot be calculated. Walrus take is below PBR and population-level effects are unlikely. Elephant seal populations are expanding so overall mortality is considered insignificant. Contributions of the groundfish fisheries to overall mortality is very small.

Availability of Prey

- **Direct/Indirect Effects.** Except for elephant seals, where the amount of prey overlap is unknown, there is very little overlap of species taken in the groundfish fisheries with prey of the pinnipeds in this group and the effects of fisheries harvest on prey species are determined to be insignificant under the FMP 1.

- **Persistent Past Effects.** Past effects on spotted seal prey include foreign, JV, and domestic groundfish fisheries, as well as state-managed fisheries for salmon and herring. For the other ice seals, elephant seals and walrus, no persistent past effects were identified, due to minimal overlap with commercial fisheries.

- **Reasonably Foreseeable Future External Effects.** Future effects were identified for state-managed fisheries for the spotted seal. Climate change may be either a beneficial or adverse factor for pinnipeds due to the potential effects of ice cover on their foraging strategies and the abundance and distribution of prey in the Bering Sea.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance of prey for pinnipeds is considered insignificant for all species. Spotted seals have some overlap of prey with the groundfish fisheries but the harvest of prey by the fisheries is not expected to have population-level effects. The amount of groundfish fishery overlap with elephant seals is unknown but, since the elephant seal population is expanding, food does not appear to be limiting so cumulative effects on prey availability are considered insignificant. The amount of prey overlap with the other pinniped species is very limited and is considered insignificant for all species in this group.

Spatial/Temporal Concentration of Fisheries

- **Direct/Indirect Effects.** Spatial and temporal fishing measures in the FMP 1 do not deviate from the baseline, and therefore have an insignificant effect on pinniped species.

- **Persistent Past Effects.** Persistent past effects on spotted seal include foreign, JV, and domestic groundfish fisheries, as well as state-managed fisheries. For other species, none are identified.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries within the range of spotted seals would be expected to be conducted in the future in a manner similar to the baseline conditions. Future effects of spatial/temporal concentration of fisheries on other species in this group would not be expected.

- **Cumulative Effects.** The spatial/temporal concentration of the groundfish fishery and all other fisheries is considered to have an insignificant cumulative effect on pinniped prey due to limited seasonal overlap. Population-level effects are unlikely for any of the species in this group.

Disturbance

- **Direct/Indirect Effects.** Similar levels of disturbance as the baseline are expected under the FMP 1 and are considered insignificant.

- **Persistent Past Effects.** Past sources of disturbance of spotted seals have been identified from the foreign, JV, and the domestic groundfish fisheries in the BSAI and state-managed fisheries for salmon. Overlap of fisheries is minimal for most species in this group. The primary source of external disturbance to the other pinniped category would be related to subsistence harvest.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries could be expected to continue at a level similar to the baseline condition. Disturbance from subsistence harvest activities in future years would be expected to be similar to the baseline conditions.

- **Cumulative Effects.** The cumulative effect of disturbance from internal and external effects is found to be insignificant for all species based on very limited overlap with the fisheries and the lack of evidence that disturbance has a population-level effect for any of these species.

4.5.8.6 Transient Killer Whales

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

With regard to incidental take, FMP 1 is not likely to result in significant changes to the population trajectory of killer whales. Six commercial fisheries in Alaska that could have interacted with transient killer whales from the western and GOA stock were monitored for incidental take by fishery observers from 1990 to 1999. Of the observed fisheries (BSAI and GOA groundfish trawl, pot, and longline), killer whale mortalities occurred only in the Bering Sea groundfish trawl and longline fisheries (Angliss *et al.* 2001) (Table 4.5-60).

In addition to mortalities caused by entanglement, killer whales are susceptible to injury or mortality through vessel strikes. One killer whale was reported to be killed when it struck the propeller of a BSAI groundfish trawl vessel in 1998 (Angliss and Lodge 2002). The mean annual mortality of killer whales incidental to groundfish fisheries from 1995 to 1999 was estimated to be 1.4 whales (Angliss *et al.* 2001). It is not known what proportion of these whales were transients versus residents. Interactions which result in the entanglement of killer whales in fishing gear are rare and are not expected to have population-level effects. The effects of entanglement and take of killer whales incidental to groundfish fisheries are rated insignificant.

Fisheries Harvest of Prey Species

The diet of transient killer whales consists of marine mammals. Because the groundfish fisheries kill very few marine mammals through incidental take, the direct effects of groundfish fisheries on the abundance of transient killer whale prey species are determined to be insignificant under FMP 1.

Spatial/Temporal Concentration of the Fishery

The spatial/temporal concentration of the groundfish fisheries does not directly affect the distribution of marine mammals. Therefore, the direct effects of the fisheries on transient killer whale prey are determined to be insignificant under FMP 1.

Disturbance

Similar levels of disturbance as that which occurred to killer whales under the baseline are expected under FMP 1. Therefore, according to the significance criteria established in Table 4.1-6, the effects of disturbance on killer whales under FMP 1 are expected to be insignificant relative to the baseline.

Cumulative Effects

The past/present effects on the transient killer whales are described in Section 3.8.22 (Table 3.8-22) and the predicted direct and indirect effects of the groundfish fishery under the FMP 1 are described above. This analysis seeks to provide an overall assessment of the species' population-level response to its environment as it is influenced by the groundfish fishery. The effects considered in this analysis are listed in Table 4.5-67. Representative direct effects used in this analysis include mortality and disturbance, with the major indirect effects of prey availability and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** With regard to incidental take, FMP 1 is not likely to result in significant changes to the population trajectory of transient killer whales.

- **Persistent Past Effects.** Mortality has been documented in the JV fisheries, domestic groundfish fisheries, state-managed fisheries, as well as reported intentional shootings. Past incidental take in the groundfish fisheries is less than 2 animals per year but it is not known if these animals were transients or residents. In addition to mortalities caused by entanglement, killer whales are also susceptible to injury or mortality through vessel strikes. The EVOS resulted in the loss of half of the individual killer whales from the AT1 transient group in PWS (Matkin *et al.* 1999). This distinct

group of whales is being evaluated for recognition as a separate stock and protection as a depleted stock under the MMPA. Contaminant levels in whales in this group were found to be many times higher than in other killer whales (Matkin *et al.* 1999).

- **Reasonably Foreseeable Future External Effects.** Future mortality is expected from external factors such as state-managed fisheries, intentional shooting, and marine pollution, particularly bio-accumulating compounds such as *para*-dichlorodephenyltrichloroethane (DDT) and polychlorinated biphenyls (PCBs) (Matkin *et al.* 2001).

- **Cumulative Effects.** The cumulative effect of mortality from internal effects of the groundfish fisheries and other external factors is unlikely to have population-level effects on transient killer whales and is therefore determined to be insignificant. The exception to this finding is the AT1 transient group in PWS. The cumulative effect of mortality was determined to be significant adverse on the AT1 group due to the past external effects of the EVOS and subsequent population decline.

Prey Availability

- **Direct/Indirect Effects.** Because the groundfish fisheries kill very few marine mammals through incidental take, the direct effects of groundfish fisheries on the abundance of transient killer whale prey species are determined to be insignificant.

- **Persistent Past Effects.** Because marine mammals are the primary prey of transient killer whales, all of the factors that have been identified as affecting the abundance or distribution of cetaceans, pinnipeds, and sea otters are pertinent in this context. These factors include commercial and subsistence harvest, intentional shootings, incidental take in all fisheries, marine pollution, climate change, and regime shifts. In addition, there is the potential for past indirect effects due to fisheries on the abundance of Steller sea lions, fur seals, and harbor seals, all of which are important prey species for transient killer whales. Declines in harbor seals in PWS after the EVOS could have affected the AT1 group of transient killer whales through their food supply (Matkin *et al.* 1999).

- **Reasonably Foreseeable Future External Effects.** Future external effects on prey species important to transient killer whales, primarily marine mammals, would likely include foreign and state-managed fisheries, subsistence harvest, marine pollution, climate change, and regime shifts.

- **Cumulative Effects.** The cumulative effects of prey availability on different marine mammal species are varied, with some populations declining substantially while others increase. Although some individual whales may focus on particular prey species, the ability of these top predators to vary their prey and forage over vast areas is believed to decrease the importance of any one species or stock of marine mammal prey in the diet of these mammals. The overall availability of prey does not appear to currently have population-level effects on transient killer whales and therefore the cumulative effect is considered insignificant.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** The spatial/temporal concentration of the groundfish fisheries does not directly affect the distribution of marine mammals. Therefore, the direct effects of the fisheries on transient killer whale prey are determined to be insignificant.

- **Persistent Past Effects.** All persistent past effects that have been identified for cetaceans, pinnipeds, and sea otters are pertinent in this context. These factors include the potential contribution of the spatial/temporal concentration of past fisheries to have caused localized depletion of prey for Steller sea lions, harbor seals, and northern fur seals with consequent population-level effects on those species.

- **Reasonably Foreseeable Future External Effects.** The future spatial/temporal concentration of external fisheries could have indirect effects on the abundance and distribution of marine mammals that are important prey for transient killer whales.

- **Cumulative Effects.** The cumulative effects of the spatial/temporal concentration of fisheries on different marine mammal species result in changes to the abundance and distribution of prey to transient killer whales. Because transient killer whales are able to vary prey and forage over vast areas, the potential localized depletion of any one species or stock of marine mammal prey is unlikely to have population-level effects on the killer whales. The cumulative effect of the spatial and temporal harvest of fish from all fisheries does not appear to be having population-level effects on transient killer whales and is therefore considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Levels of disturbance to transient killer whales are expected to be similar to baseline conditions and are therefore expected to be insignificant.

- **Persistent Past Effects.** Some levels of disturbance have likely occurred from foreign, JV, and domestic groundfish fisheries, and state-managed fisheries. Vessel traffic external to the fisheries has also contributed to overall disturbance of these animals. Effects of the level of disturbance on transient killer whales is largely unknown.

- **Reasonably Foreseeable Future External Effects.** External effects of state-managed fisheries and other vessel traffic on disturbance will likely occur in future years at a level similar to the baseline.

- **Cumulative Effects.** The cumulative effect of internal and external disturbance factors is unlikely to have any population-level effect on transient killer whales and is therefore considered insignificant.

4.5.8.7 Other Toothed Whales

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

With regard to incidental take, FMP 1 is not likely to result in significant changes to the population trajectories of toothed whales. Incidental takes attributed to the fisheries and entanglement in fishing gear and marine debris occur at low levels thought to be insignificant to toothed whale populations. The highest incidental take rate for any cetacean is that of Dall's porpoise. From 1995 to 1999 an average of 8.8 Dall's porpoise were estimated to have been taken incidental to groundfish fishing activities. The majority of these were taken in BSAI trawl fisheries while an average of 1.6 and 1.2 animals were taken in BSAI longline and

GOA trawl fisheries, respectively. Three harbor porpoise moralities were observed incidental to BSAI groundfish trawl fisheries from 1995 to 1998. The mean annual mortality of Pacific white-sided dolphins incidental to groundfish fisheries from 1995 to 1999 was estimated to be less than one animal with reported takes occurring only in the BSAI longline fishery (Angliss *et al.* 2001) (Table 4.5-60). The estimated mean annual mortality of beluga whales, endangered sperm whales, and beaked whales incidental to groundfish fisheries was zero from 1995 to 1999.

Ten non-lethal interactions with endangered sperm whales have been documented in the GOA longline fishery targeting sablefish in management zones 640 and 650 (Hill *et al.* 1999). Two of the three entanglements reported between 1997 and 2000 resulted in release of the animal without serious injury. The extent of the injuries to the third animal was not known though it was alive at the time of release. No sperm whale mortalities have been observed or reported in the BSAI/GOA groundfish fisheries since observers began collecting data in 1990 (Angliss and Lodge 2002).

In the observed fisheries (BSAI and GOA groundfish trawl, pot, and longline), killer whale mortalities occurred only in the Bering Sea groundfish trawl and longline fisheries (Angliss *et al.* 2001). The mean annual mortality of killer whales incidental to groundfish fisheries from 1995 to 1999 was estimated to be 1.4 whales (Angliss *et al.* 2001). It is not known what proportion of these whales were transients versus residents. Interactions which result in the entanglement of killer whales in fishing gear are rare and are not expected to have population-level effects.

The level of incidental takes and entanglement of these toothed whale species related to groundfish fishing activities is rare and is not expected to affect the population trajectories of any species, and is therefore insignificant at the population level.

Fisheries Harvest of Prey Species

The effects of the fisheries on toothed whale prey are largely constrained by differences between their prey and the fisheries harvest targets. FMP 1 is not expected to increase the level of competitive interactions for prey from the baseline condition and are therefore determined to be insignificant.

The beluga whale stocks along the western coast of Alaska from Bristol Bay north, and in Cook Inlet are generally restricted to shallow coastal and estuarian habitats not used by commercial groundfish fisheries. Their diet is predominantly salmonids and small schooling fishes such as eulachon and capelin. These species are taken only in small quantities as bycatch in the groundfish fisheries. Thus, it is unlikely that fishery interactions exist between beluga whales and Alaskan groundfish fisheries.

Similarly, Pacific white-sided dolphins are not commonly observed north of the Aleutian Islands, and appear to be seasonal visitors in parts of the GOA and southeast Alaska. The main body of their population is more commonly found in the central North Pacific Ocean (Ferrero and Walker 1996). With regard to diet, Pacific white-sided dolphins and Dall's porpoise feed mainly on cephalopods and small schooling fishes such as myctophids. These species are taken only in small quantities as bycatch in the groundfish fisheries.

The remaining species consume a wide variety of both fish and invertebrate species, but overlap with commercially important species is limited in most cases. Beaked whales, a diverse group unto itself, are poorly known, but available information suggests that they prey on benthic and epibenthic species including squid, skates, rattails, rockfish, and octopus. The diet of harbor porpoises in Alaskan waters is also poorly

understood, although forage consumed by stocks in the Pacific Northwest and their tendency toward near shore distribution suggest that they probably consume a variety of coastal species. None of these species are taken in significant quantities in the groundfish fisheries.

Sperm whale diet overlaps with commercial fisheries targets more than any other species in this group, but the degree of overlap is at least partly due to direct interactions with longline gear. In addition to consuming primarily medium to large sized squids, they also consume salmonids, rockfish, lingcod and skates, and in the GOA they have been observed feeding off longline gear targeting sablefish and halibut. The interaction with commercial longline gear does not appear to have an adverse impact on sperm whales since no mortalities have been observed. However, the whales appear to have become more attracted to these vessels in recent years as reliable and easy sources of food.

Most information regarding resident killer whale's consumption of commercially important groundfish results from observations of whales depredating longlines as they are retrieved in locations ranging from the southeastern Bering Sea to PWS. In the waters between Unimak Pass and the Priblof Islands, killer whales regularly strip sablefish and Greenland turbot from longlines. Consumption of other groundfish species by resident killer whales not interacting with gear is largely unknown. In general, they are opportunistic feeders with diets that differ both regionally and seasonally. Nishiwaki and Handa (1958) examined killer whale stomach contents from the North Pacific and found squid, fish, and marine mammals. The importance of these prey items in the BSAI or GOA groundfish management areas is uncertain, but there is no evidence to suggest exclusive reliance on commercially important groundfish species.

Spatial/Temporal Concentration of the Fishery

Spatial and temporal fishing measures under FMP 1 do not deviate from the baseline, which do not appear to be causing localized depletion of prey for any species of toothed whale, and are thus determined to be insignificant to other toothed whales according to the criteria established in Table 4.1-6.

Disturbance

Similar levels of disturbance to toothed whales are expected under the FMP 1 as occurred under baseline conditions, which do not appear to have population-level effects on any species. Therefore, according to the significance criteria established in Table 4.1-6, the effects of disturbance on toothed whales under the FMP 1 are expected to be insignificant relative to the baseline.

Cumulative Effects

The past/present effects on the other toothed whale species are described in Section 3.8.19 through 3.8-21 and Sections 3.8-23 through 3.8.25 (Tables 3.8-19 through 3.8-21 and Tables 3.8-23 through 3.8-25) and the predicted direct and indirect effects of the groundfish fishery under the FMP 1 are described above. The effects considered in this analysis are listed in Table 4.5-68. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** The level of mortality for toothed whale species related to groundfish fishing activities is rare and is not expected to affect the population trajectories of any of these species, and is therefore insignificant at the population level.

- **Persistent Past Effects.** Persistent past effects on species within the other toothed whale group include incidental take and entanglement in foreign, JV, and domestic groundfish fisheries and state-managed fisheries, and subsistence hunting on beluga whales. The decline of the Cook Inlet beluga population is thought to have been the result of subsistence harvests, which ranged from 21 to 123 animals per year between 1993 and 1998. Only one beluga was harvested in 2001 by hunters from the Native Village of Tyonek and one beluga was harvested in 2002 by the Cook Inlet community hunters. Belugas are incidentally taken in the state-managed salmon gillnet fisheries in Bristol Bay and Cook Inlet. One beluga was reported to be taken from the eastern Bering stock in 1996 and 7 were reported taken in Bristol Bay in 2000. In the BSAI and GOA groundfish fisheries, no mortality or serious injuries to belugas have been observed. Harbor porpoise have not been taken in the observed groundfish fisheries over a ten year period between 1990 to 1998 (Angliss and Lodge 2002). Salmon gillnet fisheries in southeast Alaska take approximately 3 individuals per year. Dall porpoise mean annual mortality was 6.0 for the Bering Sea groundfish trawl fishery, 1.2 for the GOA groundfish trawl fishery, and 1.6 for the Bering Sea groundfish longline fishery. The Alaska Peninsula/Aleutian Island salmon drift gillnet fishery has a higher take of Dall's Porpoise with an estimated 28 porpoises in one year (1990). Thousands of Pacific white-sided dolphins were killed annually between 1978 and 1991 in the high seas driftnet fisheries, which no longer occurs (Angliss *et al.* 2001). One Pacific white-sided dolphin was taken in the BSAI trawl fishery and one in the BSAI longline fishery during the same time span (Angliss *et al.* 2001). State-managed salmon gillnet fisheries take approximately 2 dolphins per year.

  Approximately 258,000 sperm whales were harvested in the North Pacific by commercial whalers between 1947 and 1987, with the highest mortality occurring in 1968 when 16,357 sperm whales were harvested, after which time the population was severely depleted. Sperm whale interactions with longline fisheries operating in the GOA are known to occur and may be increasing in frequency. Sperm whales have been known to prey on sablefish caught on commercial longline gear in the GOA. Only three entanglements have been reported in the GOA longline fishery.

  For killer whales, the combined average mortality from the observed groundfish fisheries was 1.4 whales per year (Angliss *et al.* 2001). While it is most likely that whales interacting with fisheries are from resident pods (since they eat fish), no genetic testing has been done on whales incidentally taken in the groundfish fisheries to ascertain whether they were from resident or transient stocks.

  For beaked whales (Baird's, Cuvier's, or Stejneger's), no incidental take or entanglement in BSAI and GOA groundfish trawl, longline, and pot fisheries has been documented (Angliss and Lodge 2002).

- **Reasonably Foreseeable Future External Effects.** Several of the toothed whale species range outside of the BSAI and GOA during the winter months. Therefore, foreign fisheries outside the EEZ and state-managed fisheries were identified as potential sources of mortality in the future.

Subsistence take of some stocks of beluga whales would be expected to occur in the future. Other species are not taken for subsistence purposes.

- **Cumulative Effects.** The cumulative effect of mortality from both internal and external mortality factors is considered insignificant for all non ESA-listed species due to the low level of incidental take in the groundfish fisheries and limited external human-caused mortality.

  For the endangered sperm whale, the cumulative effect was also considered insignificant because the very low level of incidental take in the groundfish fisheries or other fisheries and very limited human-caused mortality from external sources is not expected to delay the recovery of sperm whale populations.

Prey Availability

- **Direct/Indirect Effects.** The effects of FMP 1 on the toothed whales are largely constrained by differences between their prey and the fisheries harvest targets. FMP 1 is not expected to increase the level of competitive interactions for prey from the baseline condition and is therefore considered to have insignificant effects on toothed whale prey.

- **Persistent Past Effects.** Past effects on the availability of prey for this group are identified for fisheries in general and include the foreign, JV, and domestic groundfish fisheries, as well as the state-managed fisheries for salmon and herring. The diversity of diet in this whale group results in limited overlap for most species, with the possible exception of sperm whales and resident killer whales.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries were identified as an external factor having a potential effect on prey for these species in the future. Climate and regime shifts are also identified but the direction and magnitude of these effects could be either beneficial or adverse.

- **Cumulative Effects.** The ability of these whale species to forage over wide areas and on a variety of prey species moderates any potential impacts from fisheries competition. Cumulative effects on prey availability were identified for this group, including a very limited contribution from the groundfish fishery, but the degree of fishery harvest and bycatch of prey important to these whale species is not expected to have population-level effects on any species, including the endangered sperm whale, and is therefore considered insignificant.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effects.** Spatial and temporal fishing measures under FMP 1 do not deviate from the baseline, which do not appear to be causing localized depletion of prey for any species of toothed whale, and are thus determined to be insignificant.

- **Persistent Past Effects.** The spatial/temporal concentration of foreign, JV, and domestic groundfish fisheries and the state-managed fisheries are believed to have had minimal effects on the abundance and distribution of toothed whale prey.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries are expected to continue in similar manner as the under the baseline conditions. Effects of future fishing activities on toothed whale prey are expected to be minimal.

- **Cumulative Effects.** The ability of toothed whales to forage over wide areas and on a variety of prey species moderates any potential impacts from localized depletion of prey from the spatial/temporal concentration of fisheries. Cumulative effects on prey abundance and distribution, including a very limited contribution from the groundfish fishery, are not expected to have population-level effects on any species, including the endangered sperm whale, and are therefore considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Disturbance effects of on toothed whales from the groundfish fishery under FMP 1 are determined to be insignificant at the population level.

- **Persistent Past Effects.** Past potential disturbance effects on species in this group were identified for foreign, JV, and domestic groundfish fisheries, however, there is little indication of an adverse effect. General vessel traffic likely also contributes to disturbance of these species.

- **Reasonably Foreseeable Future External Effects.** Increases in the general marine vessel traffic and continued fishing activity in the state-managed fisheries were identified as potential sources of disturbance to these marine mammals.

- **Cumulative Effects.** The cumulative effect of disturbance from both internal and external effects is found to be insignificant for endangered sperm whales and other toothed whale species, based on the lack of evidence that disturbance has a population-level effect for any of these species. For sperm whales, there is growing evidence that the whales are attracted to fishing vessels as reliable and easy sources of food.

4.5.8.8 Baleen Whales

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

Incidental take of baleen whales from groundfish fishing activities is rare. A single fin whale mortality was reported in the GOA pollock trawl fishery operating south of Kodiak Island and Shelikof Strait in autumn 1999. Humpback whales are occasionally taken in the Bering Sea pollock trawl fishery through entanglement in fishing gear. The extent of interactions between bowhead whales and the groundfish fishery is not known. Rope entanglement injuries and deaths as well as ship-strike injuries appear to be rare. The extent of interactions between gray whales and the groundfish fishery are not known but some entanglement in gear does occur. Since 1989, no incidental takes of right whales are known to have occurred in the North Pacific. The low level of take of baleen whales projected to occur under FMP 1 will not affect the population trajectories of these baleen whale species, does not conflict with goals of any recovery plan for endangered whales, and is thus insignificant according to the criteria established in Table 4.1-6.

Fisheries Harvest of Prey Species

Most baleen whale species such as blue, fin, sei, and northern right whales feed primarily on copepods, euphausiids, and amphipods. Gray whales feed mostly on epibenthic and benthic invertebrates, while humpbacks and minke whales have a more diverse diet including euphausiids, Atka mackerel, sand lance, herring and capelin. The BSAI and GOA groundfish fisheries do not target these prey items (with the exception of Atka mackerel) and take very small amounts of these prey species as bycatch. Neither the abundance or distribution of zooplankton are influenced by commercial fishing operations. While a few species of baleen whales do consume herring and juvenile pollock (e.g., humpback and fin whales), changes in removal patterns of these prey species under FMP 1 would not be expected to impact their availability to whales, which can forage over vast areas and throughout the water column. The groundfish fisheries under FMP 1 are therefore unlikely to impact baleen whales through competition for prey, including the endangered blue, fin, bowhead, humpback, sei, and northern right whales.

Spatial/Temporal Concentration of the Fishery

Spatial and temporal fishing measures under FMP 1 do not deviate from the baseline, which does not cause localized depletion of prey for whales, and are therefore determined to be insignificant to both the endangered and non-ESA listed baleen whales according to the criteria established in Table 4.1-6.

Disturbance

The effects of disturbance caused by vessel traffic, fishing operations, or sound production on baleen whales in the GOA and BSAI are largely unknown. With regard to vessel traffic, most baleen whales appear tolerant, at least as suggested by their reactions at the surface. Observed behavior ranges from attraction to course modification or maintenance of distance from the vessel. Reaction to gear such as pelagic trawls is unknown, although the rarity of incidental takes suggests either partitioning or avoidance. Given their distribution throughout the fishing grounds, at least some individuals may be expected to occasionally avoid contact with vessels or fishing gear, which would constitute a reaction to a disturbance. Assuming these instances occur, the effects are likely to be temporary.

Coincident to fishing activity, as well as vessel transit, is the routine use of various sonar devices. The sounds produced by these devices may be audible to baleen whales and suggest disturbance sources. For instance, wintering humpback whales have been observed reacting to sonar pulses by moving away (Maybaum 1990, 1993), although few other cases of reaction have been documented. Given the continued occupation of the fishing grounds by these animals, and their generally positive population trends, disturbance from sonar, if it occurs in the BSAI/GOA, does not appear to have population-level effects.

Levels of disturbance to baleen whales under FMP 1 are expected to be similar to those that occurred under baseline conditions. These disturbance levels do not appear to have population-level effects on any species. Therefore, according to the significance criteria established in Table 4.1-6, the effects of disturbance on both endangered baleen whale species and other non ESA-listed baleen whales under FMP 1 are expected to be insignificant relative to the baseline.

Cumulative Effects

The past/present effects on the other baleen whale group are described in Section 3.8.11 to Section 3.8.18 (Tables 3.8-11 through 3.8-18) and the predicted direct and indirect effects of the groundfish fishery under the FMP 1 are described above. The effects considered in this analysis are listed in Table 4.5-69. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** The low level of take of baleen whales projected to occur under the FMP 1 is considered insignificant.

- **Persistent Past Effects.** Commercial whaling in the last century has had lingering effects on most of the baleen whales in this group, with the possible exception of minke whales. These include the endangered blue whales, fin whales, sei whales, humpback whales, northern right whales and the non-ESA- listed gray whale. A full discussion of the effects of commercial whaling on baleen whales is presented in Sections 3.8.11 through 3.8.18. Subsistence whaling has also affected several of the baleen whales in the past. Gray whales are harvested both in Alaska and in Russia and have a 5-year quota of 620 whales. The 1968-1993 average take for Russian and Alaska Natives combined was 159 whales per year. Bowhead whales are harvested under International Whaling Commission quotas, which allow up to 67 strikes per year, although actual strikes have been less than the quota since 1978. A single fin whale mortality was reported in the GOA pollock trawl fishery operating south of Kodiak Island and Shelikof Strait in autumn 1999. Fin whales were reported in this region year-round, most often in the summer and autumn (POP 1997). Humpback whales are present year-round in Alaska waters but are most frequently reported during the summer and autumn. In 1997, a dead humpback was found entangled in netting and trailing orange buoys near the Bering Strait. It is often difficult to determine if the entanglement occurred with active or derelict gear, or to identify the fishery the derelict gear originated from. Two mortalities (October 1998 and February 1999) were reported by observers in the Bering Sea pollock trawl fishery operating near Unimak Pass. The extent of interactions between bowhead whales and the groundfish fishery is not known. Bowhead whales are present in the Bering Sea during winter and early spring but are usually associated with ice-covered regions. Rope entanglement injuries and deaths as well as ship-strike injuries appear to be rare. Of 236 bowhead whales examined from the Alaskan subsistence harvest (from 1976 to 1992), three had visible ship-strike injuries from unknown sources and six had ropes attached or scars from fishing gear (primarily pot gear), one found dead was entangled in ropes similar to those used with fishing gear in the Bering Sea (Philo *et al.* 1992). Since 1992, additional bowhead whales have been observed entangled in pot gear or with scars from ropes. The extent of interactions between gray whales and the groundfish fishery is not known. Rope entanglement injuries and deaths as well as ship-strike injuries appear to be rare. Since 1997, five entanglements (mostly in pot gear) and one ship strike mortality have been reported in Alaska waters. Since 1989, no incidental takes of right whales are known to have occurred in the North Pacific. Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989. Because the right whale population is believed to be very small, any mortality incidental to commercial fisheries would be considered to be significant. Based on the lack of reported mortalities of endangered right whales, the estimated annual mortality rate incidental to commercial fisheries is zero whales per year from this stock.

- **Reasonably Foreseeable Future External Effects.** Foreign fisheries outside the EEZ and state-managed fisheries are expected to continue to take small numbers of baleen whales in the coming years. Entanglement in fishing gear will also continue to effect baleen whales throughout their ranges. Subsistence for gray whales and bowhead will continue to be the largest source of human-caused mortality.

- **Cumulative Effects.** Mortality is considered cumulative, based on internal effects of the fishery and contributions from external factors. The effect is considered conditionally significant adverse for endangered fin, humpback, and northern right whales based on past effects on their populations and their endangered status. This is conditional on whether take or entanglement and other human-caused mortality affects recovery or the current population trajectory. The cumulative effect is found to be insignificant for the endangered blue, bowhead, and sei whales, based on very limited interaction with fisheries and lack of adverse external factors.

  Mortality is also considered insignificant for non ESA-listed minke whales and gray whales. Population-level effects are not anticipated for any of these species.

Prey Availability

- **Direct/Indirect Effects.** The effects of FMP 1 are determined to have an insignificant effect on baleen whale species in regards to harvest of prey species due to minimal competitive overlap in species targeted by each.

- **Persistent Past Effects.** Persistent past effects on availability of prey were not identified due to the lack of competitive overlap in prey species targeted.

- **Reasonably Foreseeable Future External Effects.** Future effects were identified as state-managed fisheries such as herring, which are preyed on by humpback whales and fin whales. Other species would not be expected to be directly affected through their prey.

- **Cumulative Effects.** The cumulative effect of prey availability based on internal effects of the fishery and contributions from external factors is considered unlikely to result in population-level effects for all species in this group due to the limited overlap of prey species with the fisheries. These effects, therefore, are considered insignificant.

Temporal/Spatial Concentration of the Fishery

- **Direct/Indirect Effects.** Spatial and temporal fishing measures in FMP 1 do not deviate from the baseline, thus the effects of the spatial/temporal concentration of the fisheries under FMP 1 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects of temporal and spatial concentrations of the fisheries were not identified.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries would be expected to continue to contribute some degree of effect on several species with the baleen whales group.

- **Cumulative Effects.** The effects of spatial and temporal concentration of harvest are considered cumulative based on internal and external factors. This effect is not likely to have population-level effects due to the very low overlap in prey species for this group. The contribution of the groundfish fisheries is very slight. Cumulative effects are therefore considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Similar levels of disturbance as that which occurred to other baleen whales under baseline conditions is expected under FMP 1 and is considered insignificant.

- **Persistent Past Effects.** Some level of disturbance has likely occurred from foreign, JV, and domestic groundfish fishing, as well as state-managed fisheries along with general vessel traffic. For some species such as the gray whale and bowhead whale, subsistence activities have contributed to disturbance of these marine mammals.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries and general vessel traffic from recreational boating and whale watching to commercial vessels would be expected to continue in future years and well as subsistence activities.

- **Cumulative Effects.** The cumulative effect of disturbance from both internal and external sources is determined to be similar to the baseline condition and would not likely to result in a population-level effect for any of the species in this group. Therefore, the cumulative effect is considered to be insignificant.

4.5.8.9 Sea Otters

Direct and Indirect Effects

Incidental Take/Entanglement in Marine Debris

Sea otter interactions with fishing gear, either passive or active are infrequent. Laist (1997) reported that sea otter entanglement in marine debris is rare. Likewise, incidental takes in fishing gear occur at a rate too low to cause population-level effects. While the PBRs for the three sea otter stocks in Alaska were 871 (southeast), 2,095 (southcentral) and 5,699 (southwest), mortalities incidental to commercial fishing were 0, less than 1, and less than 2 per year, respectively (Angliss and Lodge 2002).

In southwest Alaska, the NOAA fisheries observer program reported eight kills in the Aleutian Islands black cod pot fishery in 1992 (USFWS 2002a). No other sea otter kills were reported by observers in the region from 1993 to 2000 (USFWS 2002a). USFWS petitioned NMFS to add sea otters to their annual *List of Fisheries*, (NMFS 2000b) and in 2000, sea otters appeared a "species recorded as taken in this fishery" in the BSAI groundfish trawl (Angliss *et al.* 2001). The USFWS is currently pursuing information regarding the extent of that possible interaction. The total fishery mortality and serious injury for the Alaska sea otter is considered to be insignificant (i.e., will not affect population trajectories). The effects on sea otters under the FMP 1 are considered insignificant, with respect to incidental catch and entanglement in marine debris.

Fisheries Harvest of Prey Species

The effects of the groundfish fisheries on sea otters is limited by differences between their prey and the species targeted and taken as bycatch by the fisheries. Sea otters consume a wide variety of prey species, including annelid worms, crabs, shrimp, mollusks (e.g., chitons, limpets, snails, clams, mussels, and octopus), sea urchins, and tunicates. Occasionally, groundfish (e.g., sablefish, rock greenling, and Atka mackerel) may also be consumed but invertebrates are considered the predominant elements of their diet (Kenyon 1969, USFWS 1994). Given the minor importance of groundfish in their diet, fisheries removals under FMP 1 are not expected to have significant effects on the abundance of sea otter prey and are therefore determined to be insignificant for sea otters.

Spatial/Temporal Concentration of the Fishery

The grounds for suggesting competition for forage between sea otters and commercial fisheries is weak despite the species' broad geographical distribution in the GOA and the Aleutian Islands. Sea otters inhabit waters of the open coast, as well as the bays and inside passages of southeastern Alaska. Since their primary prey items are found on the bottom in the littoral zone, to depths of 50 m, the majority of otters feed within one km of the shore (Kenyon 1969). In areas where shallow waters extend far offshore (e.g., Unimak Island), sea otters have been reported as far as 16 km offshore. They are often seen resting and diving for food in and near kelp beds (Kenyon 1969). Because of this habitat preference for shallow areas, they do not overlap spatially with groundfish fisheries. Therefore, the effects of the spatial/temporal concentrations of the fisheries are insignificant for sea otters for all of the alternative management regimes.

Disturbance

As noted for many of the other marine mammals, the effects of disturbance caused by vessel traffic, fishing operations or sound production on sea otters in the BSAI/GOA are expected to be insignificant. Sea otters exhibit considerable tolerance for vessel traffic and in some cases are attracted to small boats passing by (Richardson *et al.* 1995). Sea otters may be more tolerant of underwater sound relative to other species, owing to the greater amount of time they spend at the surface. Similar levels of disturbance as that which occurred to sea otters under the baseline conditions is expected under the FMP 1 management regime. Therefore, according to the significance criteria established in Table 4.1-6, the effects of disturbance on sea otters under FMP 1 are considered insignificant.

Cumulative Effects

The past/present effects on the sea otter are described in Section 3.8.10 (Table 3.8-10) and the predicted direct and indirect effects of the groundfish fishery under FMP 1 are described above. The effects considered in this analysis are listed in Table 4.5-70. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** The effects of incidental take and entanglement on sea otters under FMP 1 are considered insignificant.

- **Persistent Past Effects.** Commercial exploitation for pelts had a great impact on sea otters dating from the mid-1700s to the late 1800s, causing them to become nearly extinct (Bancroft 1959, Lensink 1962). Protective measures instituted in 1911 have allowed remnant groups to increase and reoccupy much of the historic sea otter range in Alaska (Kenyon 1969, Estes 1980). Residual effects from this early harvest likely persist in several areas. Alaska Natives have hunted sea otters for pelts and meat throughout history. Current harvest levels represent 9 percent of PBR for the southwestern stock, 15 percent of PBR for the southcental stock, and 35 percent of PBR for southeast stock. (USFWS 2002a, 2002b, and 2002c). In 1992, fisheries observers reported 8 sea otters taken incidentally by the Aleutian Island black cod pot fishery. During that year, only a third of the fisheries were observed, yielding an estimate of 24 otters killed in cod pot gear. No other sea otter takes were reported from observed fisheries in the range of the southwest stock from 1993 through 2000. In 1997, one sea otter was self-reported to be taken in the BSAI groundfish trawl fishery (USFWS 2002a, 2002b, and 2002c). Oils spills, such as the EVOS, can result in substantial mortality of sea otters. Sea otter numbers have declined dramatically from the Alaska Peninsula to the Bering Sea and this stock is being considered for listing under the ESA.

- **Reasonably Foreseeable Future External Effects.** Low levels of incidental take in commercial and subsistence fisheries, subsistence hunting, and periodic mortalities from oil spills are likely to continue in the future. Population-level effects from killer whale predation may continue in the southwest Alaska stock, depending on the recovery of alternate prey and behavior of whales.

- **Cumulative Effects.** The cumulative effects of mortality from all sources are different for different stocks of sea otters. The populations of the southeast and southcentral stocks of sea otters appear to be stable or increasing and are not expected to have additional mortality pressures in the future. These stocks are therefore considered to have insignificant cumulative effects from mortality. The rapid decline of the southwest Alaska stock does not appear to be the result of food shortages, disease, or toxic contamination and is likely the result of increased predation by killer whales following the collapse of their preferred sea lion prey population in the 1980s (Estes *et al.* 1998). Since the mechanism(s) of the population decline is still under investigation, the cumulative effect on the southwest stock is considered to be conditionally significant adverse.

<u>Prey Availability</u>

- **Direct/Indirect Effects.** The effects of the FMP 1 on sea otters are limited by differences between their prey and the fisheries harvest targets. As such, the effects of harvest of key prey species in groundfish fisheries are determined to be insignificant for sea otters.

- **Persistent Past Effects.** Groundfish fisheries have had little effect on the availability of prey in the past due to the limited overlap in prey species of the sea otter and the fish targeted by the groundfish fisheries. There is some minor overlap in state-managed crab fisheries and sea otter prey.

- **Reasonably Foreseeable Future External Effects.** State-managed crab fisheries that take crab from shallow waters were identified as external effects. The overlap primarily occurs in inshore areas or offshore areas with relatively shallow water.

- **Cumulative Effects.** The cumulative effect of prey availability is determined to be insignificant, based on both internal effects of the groundfish fisheries and external factors, such as the crab fisheries. This rating is due to the very limited overlap of these fisheries and the sea otter forage species, which is not likely to result in population-level effects.

Spatial/Temporal Concentration of the Fisheries

- **Direct/Indirect Effects.** The effects of the spatial/temporal concentrations of the fisheries are insignificant for sea otters for all of the alternative management regimes.

- **Persistent Past Effect.** The limited spatial overlap of groundfish fisheries and other fisheries in the past have limited their interaction with sea otter prey. Past effects of spatial/temporal concentration have likely been in very specific areas and associated with state-managed crab fisheries.

- **Reasonably Foreseeable Future External Effects.** State-managed crab fisheries are likely to continue into the future at a level similar to the baseline conditions.

- **Cumulative Effects.** The cumulative effect of the spatial/temporal harvest of prey from the internal and external effects of fisheries is considered to be insignificant, due their limited spatial overlap with sea otter habitat. These fisheries are unlikely to have population-level effects.

Disturbance

- **Direct/Indirect Effects.** Levels of disturbance under FMP 1 are expected to be similar to the baseline, which do not appear to have population-level effects on sea otters, and are therefore expected to be insignificant.

- **Persistent Past Effects.** Past effects of disturbance are primarily related to fishing and other vessel traffic as well as from disturbance associated with subsistence harvest of sea otters.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries are expected to continue at a level similar to the baseline. Vessel traffic within sea otter habitat in future years would also be expected to be similar to the baseline.

- **Cumulative Effects.** Effects of disturbance of sea otters from internal and external sources is considered insignificant and unlikely to result in any population-level effects. The contribution of the groundfish fishery to the overall cumulative effect is minimal.

4.5.9 Socioeconomic Alternative 1 Analysis

4.5.9.1 Harvesting and Processing Sector

In general, the description of FMP 1 is a 5-year (2003-2007) projection of the Alaska groundfish fisheries under the management measures approved by the NPFMC through the June 2002 Council meeting. The model and analytical framework used in the analysis of the effects of FMP 1 on the harvesting and processing sectors are described in Section 4.1.7.

Model projections of ex-vessel value and product value for this FMP are based on 2001 prices and product mixes. Actual prices may rise or decline with levels of catch, changes in market conditions, or other factors. The use of 2001 product prices and product mixes may underestimate product value for the pollock fishery (particularly the inshore component) since average product value per unit of pollock catch is expected to rise as a result of continued increases in product quality and value made possible by the AFA cooperatives. Cooperatives were in place in the catcher processor sector by 1999 but were not implemented until 2000 for the inshore and mothership sectors.

Table 4.5-71 summarizes projected impacts of FMP 1 on harvesting and processing sectors. The numbers in the table reflect the 5-year average of outcomes projected for 2003 to 2007. Primarily as a result of a projected increase in the TAC for Pacific cod in the BSAI and GOA compared to the baseline, harvests of this species are estimated to increase by about 30 percent, from 218 thousand mt to 285 thousand mt. Changes in the harvests of other groundfish species are not expected to be significant, nor are changes in total groundfish wholesale value of output, groundfish employment and groundfish payments to labor.

4.5.9.1.1 Catcher Vessels

Direct/Indirect Effects of FMP 1

Groundfish Landings by Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 catcher vessel conditions reveals that under FMP 1 there would be few significant changes in overall retained harvests of groundfish relative to the comparative baseline (Table 4.5-71). As a result of a projected increase in the TAC for Pacific cod in the BSAI and GOA, retained catches of this species are expected to increase by about 31 percent. In addition, an increase in the TAC for sablefish and rockfish (components of the Atka mackerel, rockfish, sablefish, other groundfish species [A-R-S-O] group) will result in a significant increase in the retained harvests of these species. These increases would result in a significantly beneficial effect in comparison to the baseline condition. Retained harvests of pollock and flatfish are not expected to change significantly.

Ex-Vessel Value

The total ex-vessel value of groundfish landed by catcher vessels is expected to increase relative to the comparative baseline but not significantly. Increased Pacific cod harvests by the smaller trawl catcher vessels and pot catcher vessels account for much of the increase in groundfish ex-vessel value. Longline vessels are expected to benefit from the increased catches of sablefish and rockfish.

Employment and Payments to Labor

Total groundfish employment and payments to labor by catcher vessels are expected to increase under FMP 1, but not significantly.

Impacts on Excess Capacity

No significant change in excess capacity is expected to occur under FMP 1 relative to the comparative baseline. This FMP would maintain current measures to reduce excess capacity and the race for fish in the

Alaska groundfish fisheries. Current measures that address overcapacity include the LLP, the sablefish longline fishery IFQ program, which includes provisions for community purchase of quota shares; the cooperatives established in the BSAI pollock fishery under the AFA, and the western Alaska CDQ program. These measures have been successful in limiting harvesting and processing capacity in Alaska groundfish fisheries, and further decreases in capacity in the BSAI pollock fishery and sablefish longline fishery are expected. However, no additional overcapacity measures would be implemented under this FMP. A recent report by Felthoven *et al.* (2002) indicates that significant excess capacity remains in several groundfish fisheries. This excess capacity and the use of the race for fish to allocate TAC and PSC limits among competing fishermen are expected to decrease the net benefits to the Nation from these fisheries. They are expected to do so by decreasing 1) retention rates; 2) product utilization rates; 3) product quality; and 4) the ability of harvesters and processors to take fuller advantage of seasonal demand for some seafood products, prevent seasonal market gluts, or take advantage of seasonal differences in product quality.

Average Costs

No significant change in average costs is expected to occur under FMP 1 relative to the comparative baseline. It can be assumed that the use of the race for fish to allocate TAC and PSC limits among competing fishermen in some fisheries will continue to lead to excessive fixed and variable harvesting costs in those fisheries. In addition, the existing area closures will continue to require smaller catcher vessels based out of the Alaska Peninsula, Aleutian Islands, and Kodiak communities to travel far to fish, thereby increasing transit time and operating costs. Existing bycatch reduction measures will continue to have some level of success in decreasing overall bycatch mortality but not without cost to some participants in the groundfish fisheries. Because of halibut PSC limits, portions of the annual TAC specified for most flatfish species have remained unharvested. Pacific herring PSC limits have repeatedly closed Herring Savings Areas 2 and 3 to trawl fisheries directed at pollock and rock sole, yellowfin sole, and other flatfish. Area closures for salmon and crab have also had adverse economic effects on some groundfish fisheries participants.

Fishing Vessel Safety

No significant change in fishing vessel safety is expected to occur under FMP 1 relative to the comparative baseline. The risk to fishermen is expected to remain high under this FMP. This is in part due to regulations that require fishermen to operate farther from shore or in areas and seasons with more hazardous weather conditions. In particular, the existing area closures will continue to require smaller catcher vessels based out of the Alaska Peninsula, Aleutian Islands, and Kodiak communities to travel far to fish, exposing the vessels to additional safety risks. The continued use of the race for fish to allocate TAC and PSC limits among competing fishermen in some fisheries is also expected to have an adverse effect on fishing vessel safety.

Cumulative Effects of FMP 1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish ex-vessel value, employment, payments to labor, excess capacity, average costs, and fishing vessel safety. Table 4.5-72 summarizes the cumulative effects for catcher vessels.

Groundfish Landings by Species Group

- **Direct/Indirect Effects.** Overall, retained harvests of groundfish species are not expected to change significantly compared to the baseline except for Pacific cod which is expected to increase by about 31 percent with a significantly beneficial effect in comparison to the baseline condition.

- **Persistent Past Effects.** Foreign fisheries were the first to exploit specific fish stocks and develop commercial fisheries and markets for the products; in the course of doing so, many fisheries were over-harvested, with long-term effects on stocks and the sustainable yield of specific fisheries. Foreign vessels also began using Alaska ports for services, which led to the expansion or development of commercial services and marine infrastructure in many coastal communities. Development of joint venture fisheries led to the development of domestic fish harvesting and processing capacity, through foreign and domestic investment in harvesting and processing infrastructure. Increased global demand for seafood, especially whitefish, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market contributed to increased demand for groundfish species. For more detail on persistent past effects, please see the Catcher Vessels Past/Present Effects Table 3.9-125.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue and are described in detail below.

  Many of the harvesters and processors that participate in the groundfish fishery also participate in other fisheries such as the salmon, halibut, crab, and halibut fisheries. These other fisheries provide opportunities for harvesters and processors to intercept or otherwise affect groundfish stocks and harvest quotas, and provide other sources of employment and tax revenue for local communities. Activities with these fisheries may offset or exacerbate the effects from groundfish management alternatives, in both the harvesting and processing sectors. The fisheries that have the greatest potential for cumulative effects are crab (tanner and king), salmon, halibut, and state groundfish fisheries. Several classes of catcher vessels and inshore processors currently participate in these fisheries to a certain degree, and rely on the combined harvest from these fisheries. In several communities, the processing sector handles a range of products (e.g., groundfish, crab, and salmon); in other communities they are more specialized, focusing on one or two products. Where groundfish is a primary or secondary product line, a significant, long-term decrease (as compared to cyclical) in groundfish availability could jeopardize the economic viability of harvesting and processing other fish. Given projected closures and reductions in commercial crab fisheries, and the likely continuation (or further reductions) of salmon caps, some participants in these fisheries are likely to experience adverse cumulative effects. These other fisheries also affect consumer values; their product availability provides net benefits to domestic seafood consumers. However, the extent and intensity of these other fisheries can adversely affect non-consumptive and non-use values by contributing to the actual and perceived level of fishing activities in the BSAI and GOA.

  Other economic development activities may interfere with or compete for labor, services, and facilities; or provide additional employment and revenue opportunities for local communities. Direct and indirect employment opportunities associated with economic developments may offset or exacerbate the effects from groundfish management alternatives. In addition, employment opportunities directly affect the population of a community or region, and increase demand for

municipal services and population based revenue sharing (such as education). The economic development activities that have the greatest potential for cumulative effects are state and federal oil and gas exploration/production (primarily potential exploration activities in Cook Inlet and potentially Dutch Harbor), military projects (contaminated site clean-up and missile defense projects in the Alaska Peninsula and Aleutian Islands), Kodiak rocket launch complex, tourism, and construction and operation of marine or air-related transportation projects. Such economic activities may offset short-term declines in fisheries, but are not likely to substitute for long-term declines, particularly where regional and community economies depend on fishing. In addition, economic development in coastal Alaskan communities, particularly in the Aleutian Islands and Alaska Peninsula, may be adversely affected by the designation of critical habitat for Steller's eider and Steller sea lions. This issue is already affecting construction of marine infrastructure projects and may affect other coastal activities.

Other sources of municipal and state revenue help fund local facilities and services. Within Alaska, regions and communities participating in the fishing industry generate revenue or receive revenue sharing from taxes on fishing (in some cases over 99 percent), and from non-fishing sources. Changes in these revenue streams may offset or exacerbate the effects from groundfish management alternatives. Changes in revenue streams also may affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt. The programs that have the greatest potential for cumulative effects are landing tax revenues from non-groundfish fisheries (such as salmon, crab, and halibut), power cost equalization subsidies, and municipal revenue sharing programs from the State of Alaska (including shared education funding). During recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing.

Other factors could affect price and demand for groundfish, such as the rising U.S. dollar relative to currencies of countries with high levels of groundfish imports, and adverse effect on ex-vessel values of all vessels and processors, or higher or lower global harvests of fish/seafood and fish inventories that could serve as substitutes for groundfish. Similarly, there is a link between availability of seafood industry jobs and population levels in Alaska coastal communities. These factors are difficult to predict and are not considered in this analysis.

- **Cumulative Effects.** Given the current downward trends in the commercial salmon and crab fisheries, catcher vessels that rely on a mix of groundfish, salmon and crab may experience a reduction in harvest levels. However, this cumulative effect may not result in significant changes in groundfish landings under FMP 1. An increase in TAC for Pacific cod in the BSAI and GOA is expected (49 percent), as well as for sablefish and rockfish. Harvests of pollock and flatfish are not expected to change significantly. Overall, the reductions in other fisheries, in combination with some increases in certain groundfish landings by species group, are expected to result in insignificant cumulative effects under FMP 1. Area closures and harvest limits in other fisheries can have an impact on the groundfish fisheries; however, under FMP 1 this impact is not likely to be significant. While climate change may result in potential increases or decreases in fish populations or diversity as explained in more detail in Section 4.5.10, these changes are not expected to have significant cumulative effects on groundfish landings by species group.

Ex-Vessel Value

- **Direct/Indirect Effects.** The total ex-vessel value of groundfish landed by catcher vessels is expected to increase relative to the comparative baseline but not significantly. It is expected to increase 9 percent to approximately $317 million.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings by Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings by Species Group.

- **Cumulative Effects.** Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on landing tax revenues from non-groundfish fisheries (such as salmon, crab, and halibut). During recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing. Marginal increases in ex-vessel value (10 percent) that are predicted for FMP 1 may mitigate some of the declines in other fisheries. For these reasons, insignificant cumulative effects on ex-vessel value are expected to result from FMP 1.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Overall, the change in employment is not significant. A slight increase in employment is predicted (14 percent) and is likely the result of the increase in Pacific cod harvests and ex-vessel value. Similarly, a slight increase in payments to labor is expected (10 percent), but is not significant.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings by Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** The current reductions in the salmon and crab fisheries, and the fact that many fishermen rely on participation in multiple fisheries may elevate the importance of participation in the groundfish fisheries. The increase, although slight, in groundfish employment (14 percent) under FMP 1, is likely to mitigate some of the reductions in other fisheries. Similarly, payments to labor are also projected to increase slightly (10 percent) under FMP 1 thereby mitigating some of the reductions in other fisheries. Employment and payments to labor in the salmon fisheries have been in decline in recent years and have had serious adverse effects on the fishing industry. Any reductions in the groundfish fisheries may further exacerbate this effect. However, as employment and payments to labor are not expected to change significantly under FMP 1 from the baseline, insignificant effects are likely.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** No significant changes in excess capacity are expected under FMP 1 relative to the baseline. Current measures to reduce excess capacity and the race for fish would be maintained. For further details, please refer to the direct/indirect section at the beginning of Section 4.5.9.1.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings by Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings by Species Group.

- **Cumulative Effects.** Although excess capacity still remains in other fisheries as well as the groundfish fishery, measures such as LLP and an end to the race for fish help mitigate this effect (Overcapacity Paper Appendix F-8). Assuming that these programs continue in other fisheries, as they do in the groundfish fisheries under FMP 1, no significant cumulative effects are expected for excess capacity as conditions are not expected to change substantially from the baseline.

Average Costs

- **Direct/Indirect Effects.** No significant change in average costs are expected under FMP 1 relative to the comparative baseline. It is assumed that the continued race for fish to allocate TAC and PSC limits among competing fishermen will lead to fixed and variable harvesting costs. FMP 1 measures are not expected to alter the effects of closure areas, bycatch restrictions, and PSC limits significantly from baseline conditions. More detail on average costs can be found at the beginning of this section.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal

communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings by Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings by Species Group.

- **Cumulative Effects.** Average costs in the groundfish fisheries are often associated or shared with other fisheries. Fixed costs are somewhat independent of the fisheries in that loan payments and general office and accounting expenses remain at a certain amount while ex-vessel value and product value are variable. Area closures also affect average costs through increases or decreases in transit time to fishing areas. Increases in closure areas increase costs, whereas decreases in closures usually decrease costs. Depending on area closures or the fixed or variable costs in other fisheries, when considered in combination with average costs in the groundfish fishery, significant cumulative effects may result. Should costs in other fisheries increase or decrease, vessels that are dependent on multiple fisheries are often sensitive to these changes. As FMP 1 closures do not change substantially from the baseline condition, cumulative effects on average costs in the groundfish fisheries are expected to be insignificant.

Fishing Vessel Safety

- **Direct/Indirect Effects.** Risks to fishermen are expected to remain high under FMP 1 though this is not a significant change from the baseline condition. Regulations that require fishermen to operate farther from shore and in areas or seasons with severe weather conditions continue to have an adverse effect on vessel safety.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings by Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings by Species Group.

- **Cumulative Effects.** Vessel safety is primarily a function of the race for fish, distance to fishing areas, and sea conditions, relative to vessel size. Additional closures that may result from other fisheries management measures may increase the risk to fishermen, however, these effects are not expected to be significant under FMP 1. As there are no predicted increases in area closures under FMP 1, cumulative effects on vessel safety are insignificant compared to the baseline condition.

4.5.9.1.2 Catcher Processors

Direct/Indirect Effects of FMP 1

Groundfish Landings by Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 catcher processor conditions reveals that under FMP 1 there would be few significant changes in overall groundfish catches relative to the comparative baseline (Table 4.5-71). As a result of a projected increase in the TAC for Pacific cod in the BSAI and GOA, catches of this species are expected to increase by about 24 percent and could have a significantly beneficial effect in comparison to the baseline condition. Catches of pollock, flatfish, and Atka mackerel, rockfish, sablefish, and other groundfish (A-R-S-O) species are not expected to change significantly.

Groundfish Gross Product Value

The total wholesale product value of groundfish outputs of catcher processors is expected to increase relative to the comparative baseline, but not significantly. Increased Pacific cod harvests by head-and-gut trawl catcher processors, longline catcher processors and pot catcher processors account for much of the increase in product value. The harvest of Pacific cod by surimi trawl catcher processors and fillet trawl catcher processors is limited by AFA sideboard measures that restrict the participation of AFA-eligible vessels in other groundfish fisheries to some level of historic participation.

Employment and Payments to Labor

Total groundfish employment and payments to labor by catcher processors are expected to increase under FMP 1, but not significantly.

Product Quality and Product Utilization Rate

No significant change in overall product quality or product utilization rate is expected to occur under FMP 1 relative to the comparative baseline. The product value for the BSAI pollock fishery is expected to continue to increase with the predicted rise in average product value per unit of pollock catch resulting from increases in product quality made possible by the AFA cooperatives and the end of the race for fish. The end of the race for fish is also expected to lead to further increases in product utilization rate, leading to more product per unit of fish caught. Processors that are able to generate more product from a given amount of pollock are likely increase to their gross revenue. However, the continued use of the race for fish to allocate TAC and PSC limits among competing fishermen in other groundfish fisheries is expected to result in unnecessarily low product values by decreasing product quality and utilization rates.

Excess Capacity

As with catcher vessels, no significant change in excess capacity is expected to occur under FMP 1 relative to the comparative baseline.

Average Costs

As with catcher vessels, no significant change in average costs is expected to occur under FMP 1 relative to the comparative baseline.

Fishing Vessel Safety

As with catcher vessels, no significant change in fishing vessel safety is expected to occur under FMP 1 relative to the comparative baseline.

Cumulative Effects of FMP 1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish gross product value, employment, payments to labor, excess capacity, product quality, product utilization rate, average costs, and fishing vessel safety. See Table 4.5-73 for a summary of the cumulative effects.

Groundfish Landings by Species Group

- **Direct/Indirect Effects.** Overall, retained harvests of groundfish species are not expected to change significantly compared to the baseline, except for Pacific cod, which is expected to increase by about 24 percent with a significantly beneficial effect in comparison to the baseline condition.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue and are described in detail in Section 4.5.9.1 above.

- **Cumulative Effects.** Similar to the effects experienced by catcher vessels, catcher processors that rely on a mix of groundfish, salmon, and crab may experience a reduction in harvest levels. However, this cumulative effect may not result in significant changes in groundfish landings under FMP 1. An increase in TAC for Pacific cod in the BSAI and GOA is expected (24 percent), though it is not significant. Harvests of pollock and flatfish are not expected to change significantly. Overall, the reductions in other fisheries, in combination with some increases in certain groundfish landings by species group, are expected to result in insignificant cumulative effects under FMP 1. Area closures and harvest limits in other fisheries can have an impact on the groundfish fisheries; however, under FMP 1 this impact is not likely to be significant. Other economic development activities and other sources of municipal and state revenue are not expected to contribute to cumulative effects on groundfish landings by species group. While climate change may result in potential increases or decreases in fish populations or diversity as explained in more detail in Section 4.5.10, these changes are not expected to have significant cumulative effects on groundfish landings by species group.

Groundfish Gross Product Value

- **Direct/Indirect Effects.** The gross product value is expected to increase from the baseline, but not significantly.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1 Groundfish Landings by Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above in Section 4.5.9.1.

- **Cumulative Effects.** Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on wholesale product value and landing tax revenues from groundfish and non-groundfish fisheries (such as salmon, crab, and halibut). During recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing. Marginal increases in gross product value (4 percent) that are predicted for FMP 1 may mitigate some of the declines in other fisheries. Overall, insignificant cumulative effects on ex-vessel value are expected to result from FMP 1.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Insignificant effects are predicted for catcher processors under FMP 1.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1 Groundfish Landings by Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Employment and payments to labor in the salmon fisheries have been in decline in recent years and have had serious adverse effects on the fishing industry. Any reductions in the groundfish fisheries may further exacerbate this effect. The increase, although slight, in groundfish employment (5 percent) under FMP 1, may mitigate some of the reductions in other fisheries. Similarly, payments to labor are also projected to increase slightly (5 percent) under FMP 1. Therefore, cumulative effects on employment and payments to labor are expected to be insignificant under FMP 1.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects.** No significant changes in product quality or utilization rate are expected under FMP 1 relative to the baseline.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section, Groundfish Landings by Species Group.

- **Cumulative Effects.** Advances in technology have improved product quality and utilization for various fisheries throughout the world. The end of the race for fish has also made significant differences in product quality and utilization, however, the continuation of this harvest strategy may hinder some of these improvements. Overall, increases in product quality and utilization are likely in the long-term though these improvements are not likely to result in significant cumulative effects under FMP 1.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** No significant changes in excess capacity are expected under FMP 1 relative to the baseline. Current measures to reduce excess capacity and the race for fish would be maintained.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section, Groundfish Landings by Species Group.

- **Cumulative Effects.** As with catcher vessels, excess capacity still remains in other fisheries as well as the groundfish fishery, measures such as LLP and an end to the race for fish help mitigate this effect (Overcapacity Paper Appendix F-8). Assuming that these programs continue in other fisheries, as they do in the groundfish fisheries under FMP 1, insignificant cumulative effects are expected for excess capacity as conditions are not expected to change significantly from the baseline.

Average Costs

- **Direct/Indirect Effects.** No significant change in average costs are expected under FMP 1 relative to the comparative baseline.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section, Groundfish Landings by Species Group.

- **Cumulative Effects.** Average costs in the groundfish fisheries are often associated or shared with other fisheries. Should costs in other fisheries increase or decrease, vessels that are dependent on multiple fisheries are often sensitive to these changes. Recent decreases in government subsidies, educational loan programs, and power cost sharing have indirectly increased pressure to implement or increase fish taxes as communities look for other sources of revenue. Although this can increase

average costs, this effect is not expected to be significant under FMP 1. As FMP 1 closures do not change significantly from the baseline condition, cumulative effects on average costs in the groundfish fisheries are expected to be insignificant. For more details on this discussion please refer to Section 4.5.9.1.

Fishing Vessel Safety

- **Direct/Indirect Effects.** No significant change in fishing vessel safety is expected under FMP 1.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings by Species Group.

- **Cumulative Effects.** As described under the catcher vessel section above, vessel safety is primarily a function of the race for fish, distance to fishing areas, and sea conditions, relative to vessel size. As there are no predicted increases in area closures under FMP 1, cumulative effects on vessel safety are insignificant compared to the baseline condition.

4.5.9.1.3 Inshore Processors and Motherships

Groundfish Landings by Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 inshore processor and mothership conditions reveals that under FMP 1 there would be few significant changes in overall groundfish catches relative to the comparative baseline (Table 4.5-71). As a result of a projected increase in the TAC for Pacific cod in the BSAI and GOA, catches of this species are expected to increase by about 45 percent. In addition, an increase in the TAC for sablefish and rockfish (components of the A-R-S-O species group) will result in a significant increase in the retained harvests of these species. These increases have significantly beneficial effects when compared to the baseline condition. Retained harvests of pollock and flatfish are not expected to change significantly.

Groundfish Gross Product Value

The wholesale product value of groundfish processed by inshore processors and motherships is expected to increase relative to the comparative baseline, but not significantly. Increased deliveries of Pacific cod to Bering Sea pollock shore plants, Alaska Peninsula and Aleutian Islands shore plants, Kodiak shore plants, and floating inshore processors account for much of the increase in groundfish product value. Southeast Alaska shore plants and southcentral Alaska shore plants are expected to benefit from the increased catches of sablefish and rockfish.

Employment and Payments to Labor

Total groundfish employment and payments to labor by inshore processors and motherships are expected to increase under FMP 1, but not significantly.

Product Quality and Product Utilization Rate

As with catcher processors, no significant change in overall product quality or product utilization rate is expected to occur under FMP 1 relative to the comparative baseline.

Excess Capacity

As with catcher vessels and catcher processors, no significant change in excess capacity is expected to occur under FMP 1 relative to the comparative baseline.

Average Costs

As with catcher vessels and catcher processors, no significant change in average costs is expected to occur under FMP 1 relative to the comparative baseline.

Cumulative Effects of FMP 1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish gross product value, employment, payments to labor, excess capacity, product quality, product utilization rate, average costs, and fishing vessel safety. See Table 4.5-74 for a summary of the cumulative effects.

Groundfish Landings by Species Group

- **Direct/Indirect Effects.** Overall, retained harvests of groundfish species are not expected to change significantly compared to the baseline, except for Pacific cod, which is expected to increase by about 45 percent with a significantly beneficial effect in comparison to the baseline condition.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue and are described in detail in Section 4.5.9.1.

- **Cumulative Effects.** Processors that rely on a mix of groundfish, salmon, and crab may experience a reduction in harvest levels. However, as with catcher vessels, and with catcher processors, this cumulative effect may not result in significant changes in groundfish landings under FMP 1. An increase in TAC for Pacific cod in the BSAI and GOA is expected (45 percent), as well as minor increases for flatfish and certain species in the A-R-S-O complex. Overall, the reductions in other fisheries, in combination with some increases in certain groundfish landings by species group, are expected to result in insignificant cumulative effects under FMP 1. Area closures and harvest limits in other fisheries can have an impact on the groundfish fisheries; however, under FMP 1 this impact is not likely to be significant. Other economic development activities and other sources of municipal

and state revenue are not expected to contribute to cumulative effects on groundfish landings by species group. While climate change may result in potential increases or decreases in fish populations or diversity, as explained in more detail in Section 4.5.10, these changes are not expected to have significant cumulative effects on groundfish landings by species group.

Groundfish Gross Product Value

- **Direct/Indirect Effects.** The gross product value is expected to increase from the baseline but not significantly.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above in Section 4.5.9.1.

- **Cumulative Effects.** Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on landing tax revenues from non-groundfish fisheries (such as salmon, crab, and halibut). During recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing. Marginal increases in wholesale value that are predicted for FMP 1 may mitigate some of the declines in other fisheries. For these reasons, insignificant cumulative effects on gross product value are expected to result from FMP 1.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Insignificant effects are predicted for catcher processors under FMP 1.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Employment and payments to labor in the salmon fisheries have been in decline in recent years and have had serious adverse effects on the fishing industry. Any reductions in the groundfish fisheries may further exacerbate this effect. The increase, although slight, in groundfish employment (8 percent) under FMP 1, is likely to mitigate some of the current reductions in other fisheries as described in Section 4.5.9.1. Similarly, payments to labor are also projected to increase slightly (8 percent) under FMP 1. Cumulative effects on employment and payments to labor are expected to be insignificant under FMP 1.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects.** No significant changes in product quality or utilization rate are expected under FMP 1 relative to the baseline.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section, Groundfish Landings by Species Group.

- **Cumulative Effects.** Advances in technology have improved product quality and utilization for various fisheries throughout the world. The end of the race for fish has also made significant differences in product quality and utilization, however, the continuation of this harvest strategy may hinder some of these improvements. Overall, increases in product quality and utilization are likely in the long-term, though these improvements are not likely to result in significant cumulative effects under FMP 1.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** No significant changes in excess capacity are expected under FMP 1 relative to the baseline. Current measures to reduce excess capacity and the race for fish would be maintained.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section, Groundfish Landings by Species Group.

- **Cumulative Effects.** As with catcher vessels and catcher processors, excess capacity still remains in other fisheries as well as the groundfish fishery. Measures such as the LLP and an end to the race for fish help mitigate this effect (Overcapacity Paper Appendix F-8). Assuming that these programs continue in other fisheries, as they do in the groundfish fisheries under FMP 1, insignificant cumulative effects are expected for excess capacity.

Average Costs

- **Direct/Indirect Effects.** Insignificant changes in average costs are expected under FMP 1 relative to the comparative baseline.

- **Persistent Past Effects.** For details on persistent past effects, please refer to the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section, Groundfish Landings by Species Group.

- **Cumulative Effects.** As described in more detail in Section 4.5.9.1, average costs in the groundfish fisheries are often associated or shared with other fisheries. Fixed costs are somewhat independent of the fisheries in that loan payments and general office and accounting expenses remain at a certain amount while ex-vessel value and product value are variable. Area closures also affect average costs through increases or decreases in transit time to fishing areas. As FMP 1 closures do not change significantly from the baseline condition, cumulative effects on average costs in the groundfish fisheries are expected to be insignificant.

4.5.9.2 Regional Socioeconomic Effects

The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described below. The past and present effects on regions that participate in the groundfish fishery are described in Section 3.9 (and summarized in Table 3.9-126) and below; these regions (illustrated in Figures 3.9-9 through 3.9-13) include the Aleutian Islands/Alaska Peninsula (comprised of the Aleutians East Borough and the Aleutians West Census Area, which includes the communities of Unalaska, Nikolski, Atka, Adak and the Pribilof Islands), Kodiak Island (Kodiak Island Borough, which includes the City of Kodiak) southcentral Alaska (the Kenai Peninsula Borough, Matanuska-Susitna Borough, Municipality of Anchorage, and the Valdez-Cordova Census Area, which includes the PWS region), southeast Alaska (all of the southeastern part of the state, from Yakutat Borough to Dixon Entrance), Washington inland waters (all counties bordering Puget Sound and the Strait of Juan de Fuca), and Oregon coast (Lincoln, Tillamook, and Clatsop counties, the three northernmost Oregon coastal counties). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case.

Changes in the management of the groundfish fisheries can affect regions and the communities within the BSAI and GOA in two major ways. The first category of effects, which drives the second category, are direct/indirect/cumulative impacts on segments of the fishing industry within a specific region. Potential effects of management changes on industry segments (processors, catcher processors, catcher vessels) have been analyzed in the previous section for FMP 1. Depending on where these industry segments are owned and operated, a variety of revenue (ex-vessel value, product value) and expenditure (wages, purchase of goods and services, taxes and fees) effects occur and accrue to specific regions. Because many of the segments participate in multi-species fisheries (such as salmon, crab, and halibut), the combination of potential effects from groundfish combines with effects in other fisheries, resulting in cumulative effects. Regional activities and accrual of revenues and expenditures drives effects on regional economies (including direct/indirect/induced employment and income), public revenue (local and state taxes and service charges), and to a certain degree, population and other socioeconomic characteristics.

Due to the linkages of potential effects on regions that participate in the groundfish fishery, to changes in harvest and processing levels under each of the policy alternatives and illustrative bookends, the direct and indirect effects of each alternative are based on an economic model that distributes potential effects to each of the participating regions. The representative indicators used in this analysis are based on types data that can be collected and modeled in a manner that assigns potential effects to each of the six regions. In turn, these indicators have implications and, in many cases are indicative of effects on other community characteristics that are more difficult to model, such as municipal revenue, generation and support of

secondary employment and economic activity, and potential effects on population. Potential effects are assigned by the predictive model to the region where processors and catcher vessels are located. Indicators used to assess potential effects of the alternatives and their implications are briefly described below:

In-Region Processing and Related Effects. Shore-based processors are closely tied to the region in which they are located. Much of the tax revenue generated through fish landed and processed accrues locally. While much of the processing employment is non-resident, processing activity generates demand for goods and services and stimulates secondary employment and economic development activity.

Regionally Owned At-Sea Processors. At-sea processors are tied to the region in which they are based. It is assumed that the majority of employment and tax revenue benefits also accrue to the region in which they are based, along with secondary economic activity. However, while not captured in the model, at-sea processors generate revenue and secondary economic development activity when purchasing goods and services in Alaskan ports such as Unalaska and Kodiak.

Extra-Regional Deliveries of Regionally Owned Catcher Vessels. When catcher vessels deliver their catch outside their region, they bring their earnings back into the region where they are located. These earnings translate into secondary employment and economic activities in the communities where catcher vessels are located, and are captured under the direct/indirect/induced labor and income projections.

In-Region Deliveries of Regionally Owned Catcher Vessels. When catcher vessels deliver within the region they are located, their earnings are counted as expenditures to the processors to which they deliver. While these earnings are not additive, catcher vessels delivering in-region generate secondary employment and economic activities in the communities where catcher vessels are located, and are captured under the direct/indirect/ induced labor and income projections.

Total Direct, Indirect, and Induced Labor Income and FTE Employment. This indicator measures the amount of employment by region, generated by the groundfish fishery.

For more information on the economic model used to assess direct and indirect regional effects, please refer to the economic model methodology described in Section 4.1.7 of the document.

Direct/Indirect Effects of FMP 1

FMP 1 extends the management practices and trends associated with current management of the groundfish fishery. Under FMP 1, in general there is a net overall increase in fishery socioeconomic indicator values over baseline conditions for all regions, although there is a good deal of variation the degree of increase between regions (and both increases and decreases in individual indicators within specific regions). The change in total value of processing sales (combining in-region shore processors and regionally owned at-sea processors) was beneficial, although not significant in comparison to baseline conditions. Similarly, changes in total income and total employment (combining values for in-region shore processors, regionally owned at-sea processors, and regionally owned catcher vessels) were also beneficial, but not significant under FMP 1. For the more western Alaska regions, these overall changes result from increases in Pacific cod take in both the GOA (to a lesser extent) and BSAI (to a greater extent). Within the Alaska Peninsula and Aleutian Islands region, the largest gains from the Pacific cod increases are seen in the larger shore processors. (Some decreases in variables associated with catcher vessels were seen in this region, but those are assumed to primarily be associated with a model attribution difficulty for western GOA fisheries.) For the Kodiak Island

region, the change from the baseline is largely explained by changes in Pacific cod numbers, but floating processors also benefit from sablefish associated gains. For the southcentral and southeast Alaska regions, changes in A-R-S-O, driven primarily by rockfish and sablefish, account for a good deal of the change from the baseline. These benefits are concentrated among the smaller vessel sectors, while vessels in the medium size classes also benefit from gains associated with cod. Net regional gains in the Washington inland waters region are largely associated with increases in cod as well. The following subsections provide a region-by-region summary of change under FMP 1 as compared to the baseline.

Alaska Peninsula and Aleutian Islands. Under FMP 1, total in-region groundfish processing value would increase, but not by a significant amount (with increases in the BSAI portion somewhat offset by decreases in the much smaller GOA portion of the total). In-region processing associated labor income and FTE jobs would also increase, but by less than a significant amount. Regionally owned at-sea processing value (and associated payments to labor and FTEs) would increase in percentage terms, but this is a very small sector in this region, with a negligible impact on a regional basis. The value of extra-regional and in-region deliveries by regionally owned catcher vessels would decrease, with relatively large decreases seen for in-region deliveries, but again this is understood to be in large part an artifact of the modeling output, so these decreases are considered less than significant. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would decrease but by a less than significant amount. For in-region deliveries, catcher vessel payments to labor and FTEs would both appear to decrease by a significant amount, but as with delivery data, this is considered to be an apparent rather than a real decrease. For both extra-regional and in-region catcher vessel deliveries, the absolute values for this region are relatively small. With respect to the relative importance of the different sectors to net regional impacts, the in-region processing related activity accounts for the vast majority of fishery associated labor income and FTEs, so the increases seen in processing values would be disproportionately important in relation to changes seen in the other sectors. (Further, in-region processing value may be taken as a proxy for regionally important municipal and borough revenues generated by local fish taxes.) The total regional direct, indirect, and induced labor income and FTE employment would increase under this FMP, but by less than a significant amount (from a base of $226 million in labor income and 4,796 FTEs). FMP 1 is considered to result in largely beneficial, but less than significant impacts for the region as a whole.

Kodiak Island. Total in-region groundfish processing value would increase by about 23 percent under this FMP (with higher values for both BSAI and GOA, but BSAI values are not a significant portion of the regional total). Associated labor income and FTE jobs would also increase by 23 percent. Regionally owned at-sea processing value would increase, but by less than a significant amount (with the vast majority of the increase attributable to changes in BSAI values), and associated labor income and FTEs would both increase to about the same degree. (In this region under baseline conditions, in-region processing accounts for about three-quarters of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-quarter of the total; labor income and FTEs distribution between these processing sectors follow a similar pattern.) The value of extra-regional deliveries would increase, but not significantly, while in-region deliveries by regionally owned catcher vessels would increase by about 30 percent. Catcher vessel payments to labor increases would be beneficial, but less than significant, while FTE jobs associated with extra-regional deliveries would increase by about 25 percent. For in-region deliveries, catcher vessel payments to labor and FTEs would increase by about 30 and 23 percent, respectively, but over a smaller base than seen for extra-regional deliveries. On a regional basis, catcher vessel activity is a relatively more important component of fishery associated labor income and FTEs than was seen in the Alaska Peninsula/Aleutian Islands region, but processing activity still dominates these categories in the regional totals. The total regional direct, indirect, and induced labor income and FTE employment would both

increase by about 21 percent under this FMP (from a base of $66 million in labor income and 1,600 FTEs). FMP 1 has consistently beneficial impacts for the Kodiak Island region, with some significantly beneficial impacts on both a local sector and regional (or community) basis.

Southcentral Alaska. Total in-region groundfish processing value would increase by 35 percent (all attributable to GOA increases). Associated labor income and FTE jobs would also increase by 35 percent. Regionally owned at-sea processing value would increase, but by a less than significant amount (with both BSAI and GOA values increasing), and associated labor income and FTEs both increasing by a similar amount. (In this region under baseline conditions, in-region processing accounts for about four-fifths of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-fifth of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea sector.) The value of extra-regional and in-region deliveries by regionally owned catcher vessels would increase by 30 and 58 percent, respectively. Catcher vessel payments to labor and FTE jobs associated with extra regional deliveries would increase by about 30 and 32 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would increase by about 58 and 68 percent, respectively. In this region, catcher vessel associated FTE jobs far surpass processing FTEs in the regional totals, but payments to labor for processing still surpass those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income would increase by about 31 percent and FTE employment would increase by about 33 percent (from a base of $23 million in labor income and 567 FTEs). FMP 1 has consistently beneficial impacts for the southcentral Alaska region, with some significantly beneficial impacts on both a local sector and regional (or community) basis, although a relatively low level of groundfish dependency in local economies within this region tends to lessen what would otherwise appear to be a relatively large overall impact.

Southeast Alaska. Total in-region groundfish processing value would increase marginally (all attributable to GOA increases), as would associated labor income and FTE jobs (but both remain relatively small values). Regionally owned at-sea processing value would increase (with increases in BSAI values offset to a degree by declines in GOA values) as would associated labor income and FTEs, but none of these increases would rise to the level of significance. (In this region under baseline conditions, in-region processing accounts for about seven-tenths of the combined processing total value of sales and regionally owned at-sea processing accounts for about three-tenths of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea sector.) The value of extra-regional deliveries by regionally owned catcher vessels would increase somewhat (but by less than a significant amount), and in-region deliveries by regionally owned catcher vessels would remain about the same. Catcher vessel payments to labor and FTE jobs associated with extra regional deliveries would increase; for in-region deliveries, catcher vessel payments to labor would remain the same and FTEs would also increase but while all of these changes are beneficial, none are large enough to be considered significant. For this region, catcher vessel FTE employment far outpaces processing related employment, but payments to labor for processing still outpace those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income and FTE employment would increase, but not by amounts considered significant (from a base of $34 million in labor income and 879 FTEs). FMP 1 has consistently beneficial impacts for the southeast Alaska region, but none of these impacts are considered significant on a local sector or regional basis.

Washington Inland Waters. Total in-region groundfish processing value changes are negligible on a regional basis due to low baseline values and small changes from the baseline. Associated labor income and FTE jobs would increase by large percentages, but their overall low value render these changes not significant. Regionally owned at-sea processing value would increase (with increases in BSAI offset somewhat by decreases in GOA values, although GOA values are comparatively very small), and associated labor income and FTEs would increase as well, but none of these changes rise to the level of significance. The value of extra-regional and in-region deliveries by regionally owned catcher vessels would increase, but by relatively small amounts. Catcher vessel payments to labor and FTE jobs associated with extra regional deliveries would also increase, but by less than significant amounts. Similarly, for in-region deliveries, catcher vessel payments to labor and FTEs would both increase, but by less than significant amounts. In this region, processing dominates the regional labor income and FTE employment totals when compared to analogous catcher vessel figures, but it is important to note that catcher vessel totals are still far higher for this region than for any other. The total regional direct, indirect, and induced labor income would increase, as would FTE employment (from a base of $557 million in labor income and 10,316 FTEs), but these increases are not large enough to be considered significant. FMP 1 has consistently beneficial impacts for the Washington inland waters region, but none of these impacts are considered significant on a local sector or regional basis.

Oregon Coast. Total in-region groundfish processing value changes are zero, along with associated labor income and FTE jobs, as there is no activity under baseline conditions or under this FMP. Similarly, there are no regionally owned at-sea processors under baseline conditions or foreseen under this FMP, so all processing values, labor income, and FTE job values are zero. The value of extra-regional deliveries by regionally owned catcher vessels would increase, as would associated labor income and FTE jobs, but the amounts of these increases are considered less than significant. There is no in-region activity by catcher vessels owned in this region, so all values for product, labor income, and FTE jobs are zero under both baseline conditions and this FMP. The total regional direct, indirect, and induced labor income would increase, as would FTE employment (from a base of $15 million in labor income and 318 FTEs), but none of these increases are considered significant. FMP 1 has consistently beneficial impacts for the Oregon coast region, but none of these impacts are considered significant on a local sector or regional basis.

Cumulative Effects of FMP 1

See Table 4.5-75 for a summary of the cumulative effects on regions and communities under FMP 1.

In-Region Processing and Related Effects

- **Direct/Indirect Effects.** Direct/indirect effects are considered insignificant for the Alaska Peninsula/ Aleutian Islands, southeast Alaska, Washington inland waters, and Oregon coast regions; effects on Kodiak Island and southcentral Alaska are considered significantly beneficial. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. These effects are summarized below:

  Fishing trends and developments such as allocation of groundfish between inshore and offshore processors, establishment of the CDQ program, and passage of the American Fisheries Act have established the current involvement of regions and communities in the fishery. The domestic

groundfish fisheries have matured to provide significant contributions to regional economies. The economies of the Alaska Peninsula/Aleutian Islands and Kodiak Island regions are heavily dependent on fishing and groundfish in particular; the economies of the other Alaskan, Washington, and Oregon regions are more diversified, and fishing provides a significantly smaller contribution to these regions.

Municipal and State Revenues: Taxes on groundfish landed and processed have become a significant source of shared revenue to local municipalities and the State of Alaska, and have contributed to municipal revenue amounts ranging from $1.3 million in the Kodiak Island region to over $7 million in the Alaska Peninsula and Aleutian Islands. Several municipalities also have fuel transfer taxes where vessels participating in the groundfish fishery generate local revenue. Furthermore, real and personal property tax on both onshore processing facilities and fishing vessels generate additional revenues for specific municipalities. Revenues directly resulting from local landings or groundfish processing are not the primary basis for local taxation in the southcentral and southeast Alaskan regions, although both received shared fish tax revenue from the state. Communities also rely on fish tax from the halibut, salmon, and crab fisheries. Downturns and closures in the latter two fisheries have resulted in loss of revenue for many communities in the three years. Revenue sharing from the State of Alaska to municipal government, through programs such as Power Cost Equalization and capital facility construction funds, have also been decreasing in recent years, forcing communities to rely more on local sources of revenue. The availability of state and local revenue has funded public services, and construction of public facility and infrastructure projects, generating local income and employment.

- **Reasonably Foreseeable Future Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are summarized below:

  Other state and federal fisheries, which may provide other fishing opportunities to vessels and processors participating in the groundfish fishery, intercept or otherwise affect groundfish stocks and harvest quotas, and provide other sources of employment and tax revenue for local communities. Activities associated with these fisheries may offset or exacerbate the effects from groundfish management alternatives, in both the harvesting and processing sector. The fisheries that have the greatest potential for cumulative effects are crab (tanner and king), salmon, halibut, and state groundfish fisheries; herring and scallops interact to a lesser degree. Several classes of catcher vessels and inshore processors currently participate in these fisheries to a certain degree, and rely on the combined harvest from these fisheries. However, entry of additional vessels into the salmon and halibut fisheries is currently limited by permit; participation in the crab fisheries is limited by vessel size, gear requirements, and license to participate in the fishery. In several communities, the processing sector handles a range of product (groundfish, crab and salmon); in other communities they are more specialized, focusing on one or two products. Where groundfish is a primary or secondary product line, a significant decrease in groundfish availability could jeopardize the economic viability of processing other fish.

  Projected closures and/or rationalization of quota for commercial crab fisheries may adversely affect fishery participants in specific communities, particularly depending on what years of fishery participation are chosen as the qualifying years to determine eligibility and quota. It may also

adversely effect service suppliers in the short-term that are currently geared for meeting peak demands created by the race for fish. Given the projected continuation in reduced demand and prices for Alaskan salmon, some participants in these fisheries are experiencing significantly adverse effects, as are communities that rely on the salmon fishery for employment and income, secondary economic activity, and municipal revenue. The halibut fishery has been relatively stable in terms of stock size and price; this stability is expected to continue. Changes in state groundfish quotas could have beneficial or adverse effects on vessels and processors, depending on the alternative.

Other economic development activities may interfere with or compete for labor, services, and facilities; or provide additional employment and revenue opportunities for local communities. Direct and indirect employment opportunities associated with economic developments may offset or exacerbate the effects from groundfish management alternatives. In addition, employment opportunities directly affect the population of a community or region, and increase demand for municipal services and population based revenue sharing (such as education). The economic development activities that have the greatest potential for cumulative effects are oil and gas exploration and production (primarily potential exploration activities in Cook Inlet, and potentially out of Dutch Harbor), military projects (contaminated site clean-up and missile defense projects in the Alaska Peninsula and Aleutian Islands), tourism, and construction of public marine or air-related transportation projects. Reduced levels of state and municipal funding is having an adverse effect on employment and support activities that are typically created by public projects, particularly in Alaska.

Other sources of municipal and state revenue may help fund construction and operation of local facilities, and provide services. Within Alaska, regions and communities participating in the fishing industry generate revenue or receive revenue sharing from taxes on fishing (in some cases over 99 percent), and from non-fishing sources. The level of income differs depending whether or not municipal governments levy a raw fish tax on ex-vessel value landings, or tax fuel transfer or other fisheries related services. Changes in these revenue streams may offset or exacerbate the effects from groundfish management alternatives. Changes in revenue streams may affect the communities' ability to provide municipal services, fund capital projects, borrow money, and retire debt service. The programs that have the greatest potential for cumulative effects are revenues from landing taxes on non-groundfish fisheries (such as salmon, crab, and halibut), power cost equalization, and municipal revenue sharing programs from the State of Alaska (including shared education funding). During recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing. The dramatic downturn in the salmon industry, coupled with state budget cuts to address a deficit are likely to continue to adversely affect many Alaskan coastal communities.

Other natural factors may affect the productivity of groundfish and other fisheries upon which regions and communities depend. These factors would include short-term cyclic changes and long-term climate changes.

- **Cumulative Effects.** Cumulative effects on in-region processing and related characteristics, such as municipal revenue and secondary economic development, are generally insignificant. The influence of external factors is adverse for the most part, which offset increases in in-region processing. The exception occurs in portions of the Alaska Peninsula, where increases in processing due to gains in Pacific cod are overshadowed by external factors. Trends in multi-species fisheries

and other sources of municipal and state revenue, primarily due to the downturn in salmon and reductions in state and municipal revenue, result in conditionally significant adverse effects on in-region processing and municipal revenue. The Kodiak and southeast Alaska region is experiencing similar declines in the salmon industry and municipal revenues; however, with a more diversified economy and larger population base, adverse effects are not as severe, and are considered insignificant.

Regionally Owned At-Sea Processors

- **Direct/Indirect Effects.** Direct /indirect effects are considered insignificant for all six regions. See the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and to a lesser extent, trends in state and municipal revenue. At-sea processors are affected by changes that have occurred in the groundfish industry related to allocation, and by their participation in multi-species fisheries. However, participation in multi-species fisheries is low compared most Alaskan at-sea processors. As the majority of at-sea processors are owned by Washington State residents, tax revenue generated is not as significant a factor on a local or regional basis.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. Given the limited participation in multi-species fisheries and the relatively diversified economy in Washington, where the majority of at-sea processors are based, external reasonably foreseeable future affects are not likely to have much of a contribution to cumulative effects.

- **Cumulative Effects.** Cumulative effects on in-region processing and related characteristics, such as municipal revenue and secondary economic development, are generally insignificant. Direct/indirect effects are insignificant for all regions. Reasonably foreseeable external effects will not contribute much to cumulative effects, except in Kodiak, where most of the Alaska at-sea processor fleet is based. As indicated previously, with a more diversified economy and population base, cumulative effects will be insignificant.

Extra-Regional Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects.** Direct/indirect effects are insignificant for the Alaska Peninsula/ Aleutian Islands, Kodiak Island, southeast Alaska, Washington inland waters, and Oregon coast regions; effects on southcentral Alaska are considered significantly beneficial. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. Catcher vessels are affected by changes that have occurred in the groundfish industry related to allocation and AFA sideboards, and by their participation in multi-species fisheries, particularly salmon, crab, and halibut. For more detail, see the discussion of persistent past effects under In-Region Processing.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all alternatives; for more detail, see the discussion of persistent past effects under In-Region Processing.

- **Cumulative Effects.** Extra-regional deliveries of regionally owned catcher vessels decrease but are considered to be cumulatively insignificant; vessels that participate in multi-species fisheries such as crab and salmon, may experience conditionally significant adverse cumulative effects, and are primarily based out of the Alaska Peninsula/Aleutian Islands and Kodiak. Reductions in state and municipal revenue, and limits on other economic development activity besides fishing are likely to further contribute to cumulative adverse effects in the Alaska Peninsula and Aleutian Islands.

In-Region Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects.** Direct indirect effects are insignificant for the Alaska Peninsula/Aleutian Islands, southeast Alaska, Washington inland waters, and Oregon coast regions; effects on southcentral Alaska and Kodiak Island are considered significantly beneficial. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. Catcher vessels are affected by changes that have occurred in the groundfish industry related to allocation and AFA sideboards, and by their participation in multi-species fisheries, particularly salmon, crab, and halibut. For more detail, see the discussion of persistent past effects under In-Region Processing.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities., other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators, for all alternatives.

- **Cumulative Effects.** In-region deliveries of regionally owned catcher vessels are likely to decrease, but are considered to be cumulatively insignificant; vessels that participate in multi-species fisheries such as crab and salmon may experience conditionally significant adverse cumulative effects, and are primarily based out of the Alaska Peninsula/Aleutian Islands and Kodiak. Reductions in state and municipal revenue and limits on other economic development activity besides fishing are likely to further contribute to cumulative adverse effects in the Alaska Peninsula and Aleutian Islands.

Total Direct, Indirect, and Induced Labor Income and FTE's

- **Direct/Indirect Effects.** Direct, indirect, and induced labor income and employment is likely to increase for all regions. Significant increases are expected for Kodiak Island and southcentral Alaska. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, trends in state and municipal revenue, and public infrastructure and facility projects. Fishing is a major component of income and employment in many small Alaskan coastal communities. Federal,

state, and local revenue has funded public infrastructure and facility projects that generate income and employment in many regions and communities. For more detail, see the discussion of persistent past effects under In-Region Processing.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators, for all alternatives.

- **Cumulative Effects.** Direct, indirect, and induced labor income and employment is likely to increase in all regions, including a significant increase for Kodiak Island and southcentral Alaska. Within Washington and Oregon, fisheries are a small part of the regional economies and effects are dwarfed by other trends. Trends in other fisheries (particularly salmon) and reductions in municipal revenue decrease labor income and employment, particularly in the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Cumulative effects are insignificant in most regions, except in the Alaska Peninsula and Aleutian Islands, where cumulative effects are conditionally significant adverse.

4.5.9.3 Community Development Quota Program

The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described below. The past and present effects on CDQ are described in Section 3.9 (Table 3.9-126) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case (Table 4.5-76). The representative indicator used in this analysis is the allocation of catch to CDQ groups. It should be noted that the allocation reflects potential revenue to CDQ groups, and indirectly the potential funds that are available for approved economic development activities in CDQ communities.

Direct/Indirect Effects of FMP 1

Under this FMP, 7.5 to 10 percent of all BSAI groundfish quotas would continue to be apportioned under the CDQ program to the 65 eligible western Alaska communities through the established CDQ groups. It is assumed that the multi-species CDQ program and quotas would continue as well. Under this FMP, TAC increases, so no adverse impacts to the CDQ program or regions are anticipated.

Cumulative Effects of FMP 1

Cumulative effects on CDQ for FMP 1 are summarized in Table 4.5-76.

CDQ Allocations

- **Direct/Indirect Effects.** The direct/indirect effects of FMP 1 on the CDQ program are insignificant.

- **Persistent Past Effects.** The past/present effects on the CDQ program for groundfish fisheries occur within the BSAI coastal region. Management actions taken include: persistent limitations on economic development and associated employment activities; 1992 CDQ program established during inshore/offshore pollock fishery allocation process; 1995 BSAI halibut and sablefish CDQ implemented (7.5 percent of TAC); 1996 program incorporated into MSA; 1998 AFA increased

CDQ pollock allocation to 10 percent of TAC, initial pollock allocation set at 7.5 percent of TAC; and 1998 multi-species groundfish CDQ program implemented (7.5 percent of TAC). The comparative baseline statement for CDQ includes the 65 ANCSA communities in 6 CDQ regions that participate in the program. Program benefits include flow of royalties, employment, and income to areas typically characterized by limited commercial economic opportunities. CDQ investment has resulted in increased participation in both regional and local fisheries. Past/present effects for CDQ groups include the effects of stock levels and fishery closures in other fisheries where CDQ groups have quota share, primarily in crab and halibut. Natural fluctuations in these stocks drive fishery opening and closures. As species and percent for which share has been allocated to CDQs increases, the involvement in multi-species fisheries increases.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities, and other sources of municipal and state revenue all have the potential to affect the CDQ program adversely or beneficially. Many harvesters and processors participate in salmon, crab, federal groundfish, and halibut. Crab CDQ groups will likely benefit due to rationalization of that fishery as CDQ shares are projected to rise. CDQ groups participating in salmon fisheries will be adversely effected because price is down and runs vary. Halibut share of CDQ groups will hold stable. Other economic development activities will be effected by community infrastructure projects creating employment and income opportunities. Currently the trends in funding available to CDQ communities are somewhat offsetting. There are funds available for infrastructure improvement through the Denali Commission, but state revenue sharing and related projects are generally decreasing. Changes in federal and state fiscal policies are likely to occur and effect CDQ communities. Long-term climate change and regime shifts will continue to influence the openings and closures of groundfish and other fisheries where CDQ groups are participants.

- **Cumulative Effects.** Under FMP 1, a cumulative effect is identified for the CDQ Program, and the effect is judged to be insignificant. With guaranteed CDQ shares through the CDQ program, no significantly adverse cumulative impacts to the CDQ program are expected.

4.5.9.4 Subsistence

The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described below. The past/present effects on subsistence are described in Section 3.9 (Table 3.9-126) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case (Table 4.5-77). The representative indicators used in this analysis are other fisheries such as foreign, JV, domestic, and state-managed fisheries, other economic development activities, sport and personal use, and long-term climate change and regime shift.

Direct/Indirect Effects of FMP 1

Potential impacts to subsistence fall into four main categories: subsistence use of groundfish, subsistence use of Steller sea lions, subsistence use of salmon in western Alaska and bycatch in the groundfish fisheries, and indirect impacts on other subsistence activities, specifically the loss of income that would be otherwise directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would otherwise be available for joint production opportunities. Under this FMP, no changes in the commercial fishery are anticipated that would result in impacts to baseline subsistence groundfish fishing conditions. There is also no indication that this FMP would have an adverse impact on Steller sea lion subsistence

activities. Salmon bycatch would essentially remain the same as under baseline conditions and is determined to have no significantly adverse effects on the return of salmon to western Alaska rivers; therefore no significantly adverse impacts to subsistence salmon fisheries are expected to result. Catcher vessel activity and labor income are anticipated to be neutral or increase under this FMP; therefore no adverse indirect impacts to subsistence through a decline in income or joint production opportunities are expected to occur.

Cumulative Effects of FMP 1

The predicted direct and indirect effects of the groundfish fishery under the FMP 1 are described above. The past/present effects on subsistence are described in Section 3.9. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. Representative indicators used in this analysis are the same as those used in the direct and indirect analysis, and include subsistence use of groundfish, subsistence use of Steller sea lions, subsistence use of salmon, and indirect impacts on other subsistence activities such as income and joint production opportunities (Table 4.5-77).

Subsistence Use of Groundfish

- **Direct/Indirect Effects.** Under this FMP, no changes in the commercial fishery are anticipated that would result in significantly adverse impacts to baseline subsistence groundfish fishing conditions.

- **Persistent Past Effects.** Foreign, JV, domestic, and state-managed fisheries have decreased populations of some species of groundfish used for subsistence. The comparative baseline indicates that groundfish makes a relatively modest contribution to the total subsistence resource base, but comprises up to 9 percent of the base in some commercial groundfish communities.

- **Reasonably Foreseeable Future External Effects.** Other fisheries have a potential to adversely contribute to the groundfish fisheries. The state-managed groundfish fishery activity could impact subsistence groundfish fishing. Other economic development activities and sport and personal use of subsistence use of groundfish do not significantly contribute potential effects on the subsistence use of groundfish. There are relatively low levels of subsistence use of groundfish in comparison to other fish resources. Infrastructure development, and sport use, and personal use are unlikely to cause a decline in groundfish stocks. Long-term climate change and regime shift have the potential to adversely affect groundfish stocks due to the natural fluctuations in groundfish stocks.

- **Cumulative Effects.** Under FMP 1, a cumulative effect is identified for subsistence use of groundfish, but is judged to be insignificant. The external impacts of economic development activities, sport use, and personal use of subsistence groundfish are not likely to contribute to significantly adverse cumulative effects on the groundfish fisheries. However, other state-managed fisheries could have adverse impacts on the subsistence use of groundfish due to the direct competition for the same species, but are not considered to be significant. The long-term climate change could adversely affect groundfish stocks.

Subsistence Use of Steller Sea Lions

- **Direct/Indirect Effects.** There is no indication that this FMP would have an adverse impact on Steller sea lion subsistence activities or take over baseline conditions.

- **Persistent Past Effects.** The past/present effects on subsistence use of Steller sea lions include the following: a long-term decline in population of Steller sea lions due to a number of factors; while sea lions have been used for subsistence since pre-contact times, there has been a long-term decline in relative importance of marine mammals in local diets; and commercial groundfish fishing takes prey species utilized by Steller sea lions, although the relative impact of this interaction is the subject of continuing research. With regard to past and present management actions, the MMPA (1972) limits subsistence take to Alaska Natives. The Steller sea lion population west of 144 degrees west longitude was declared endangered in 1990 (and populations east of line were declared threatened). The subsistence use of Steller sea lions reduces the number of Steller sea lions as does any other activity that results in Steller mortality, but by definition, but Steller subsistence use may not be directly related to overall Steller population decline. Most activity occurs in communities in the southwest portion of the state, although a significant number of Steller sea lions are harvested in a handful of other communities.

- **Reasonably Foreseeable Future External Effects.** Other commercial federal and state fisheries compete for sea lion prey and are likely to adversely contribute to the state of the sea lion population. Subsistence uses of Steller sea lions are not likely to adversely contribute to the groundfish fisheries. Other economic development activities and long-term climate change and regime shifts could adversely contribute to Steller sea lion subsistence activities. Community marine port and harbor development could potentially impact habitat and increase Steller sea lion disturbance. Long-term climate change could potentially effect recovery of Steller populations.

- **Cumulative Effects.** Under FMP 1, while an adverse cumulative effect is identified for subsistence use of Steller sea lions, the effect is judged to be insignificant. However, the cumulative effects of take, the continuing endangered status, and long-term decline in abundance are likely having population-level effects, but not enough to have significant indirect impacts to subsistence. The external impacts of other fisheries, other economic development activities, and subsistence uses of Steller sea lions are not likely to contribute adversely to the groundfish fisheries.

<u>Subsistence Use of Western Alaskan Salmon and Bycatch in the Groundfish Fishery</u>

- **Direct/Indirect Effects.** Under this FMP, salmon bycatch would essentially remain the same as under baseline conditions, therefore adverse direct/indirect impacts to subsistence salmon fisheries are expected to be insignificant.

- **Persistent Past Effects.** Salmon has been utilized for subsistence since pre-contact times; salmon bycatch in the groundfish fishery raises concerns especially during years of poor runs in western Alaska, but current data does not allow for a clear demonstration of the significance of adverse impact. Other past and present management actions include the adverse contribution of commercial salmon fishing on subsistence use of salmon; Area M salmon fishing closures were implemented to decrease intercept of salmon returning to areas further west and north. The comparative baseline statement for subsistence use of salmon indicated that it is part of the household economic base and sociocultural institutions in dozens of communities in western and interior Alaska.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities, and long-term climate change and regime shifts could all adversely contribute to effects on salmon subsistence activities. Salmon intercept from other commercial fisheries has the potential

to contribute to poor salmon returns in western Alaska. Other economic development activities and community infrastructure development could potentially effect salmon spawning and rearing habitat. Long-term climate change could potentially effect at-sea salmon survival and reduce salmon runs. Sport and personal use or subsistence use of salmon is not likely to contribute to adverse effects on the salmon population.

- **Cumulative Effects.** Under FMP 1, a cumulative effect is identified for subsistence use of salmon, and is judged to be adverse but insignificant. However, given the depressed stock status of salmon runs in western Alaska, adverse contributions from external factors, and the salmon bycatch in the BSAI and GOA, sustainability of depressed salmon stocks could be adversely impacted, but are considered insignificant.

Indirect Impacts on Other Subsistence Activities (Income and Joint Production Opportunities)

- **Direct/Indirect Effects.** Under this FMP, catcher vessel activity and labor income are anticipated to be neutral or increase, therefore no adverse indirect impacts to subsistence through a decline in income or joint production opportunities are expected to occur.

- **Persistent Past Effects.** The past/present effects on the indirect impacts on other subsistence activities include a history of joint production as a part of local groundfish and other commercial fishery activities; and income from fishing used for investment in subsistence similar to use of income from other activities. The comparative baseline statement for indirect impacts on other subsistence activities indicates that joint production activity has been largely undocumented; activity that does occur is primarily associated with the smaller vessel classes within the fleet; vessels used as a platform or to access a number of subsistence activities in addition to fishing (e.g., hunting and berry picking).

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities, and long-term climate change and regime shifts could all adversely or beneficially contribute to indirect subsistence activities. Other fisheries and other economic development activities could potentially effect income available for pursuit of subsistence activities. For example, current reductions in salmon fishing due to lower prices is likely to reduce joint production opportunities. Long-term climate change could potentially effect groundfish stocks and opportunity for joint production and income. Effects of sport and personal use on indirect subsistence activities is minimal.

- **Cumulative Effects.** Under FMP 1, a cumulative effect is identified for indirect subsistence use, and the effect is judged to be insignificant. Catcher vessel activity, and joint production opportunities are not expected to be affected adversely. However, the external impacts of other fisheries, other economic development activities, and long-term climate change and regime shifts could potentially contribute adversely to the indirect subsistence use.

4.5.9.5 Environmental Justice

The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described below. The past and present effects on Environmental Justice are described below (Table 3.9-126). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative

case. The external effects used in this analysis are other fisheries such as foreign, JV, domestic, and state-managed fisheries, other economic development activities, other sources of municipal and state revenue, and long-term climate change and regime shift (Table 4.5-78).

Direct/Indirect Effects of FMP 1

Potential impacts that drive Environmental Justice issues include employment/municipal revenue in communities with significant percentages of special populations (Alaska Native and minority processing workforce); revenue to Alaska Native-owned catcher vessels; revenue to Alaska Native-owned catcher processors; subsistence activities associated with groundfish, Steller sea lion, and salmon; and the loss of income from fishing that would be otherwise directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would otherwise be available for joint production opportunities. The regions that could experience potential impacts include the Alaska Peninsula and Aleutian Islands, Kodiak Island, southcentral Alaska, southeast Alaska, Washington inland waters, Oregon coast, the CDQ regions, and western Alaska communities that harvest salmon for subsistence purposes.

Alaska Peninsula and Aleutian Islands. As described in existing conditions, this region encompasses a number of groundfish fishing communities, of which a number have predominately Alaska Native populations. Also as described under existing conditions, the in-region processing workforce is predominantly a minority population. In-region processing employment would increase over baseline conditions by about 204 jobs; therefore, no Environmental Justice impacts would result. Total in-region groundfish processing value would increase from $464 million to $492 million. Increased in-region processing value would correspond to additional municipal revenue and taxes to the local communities and therefore no associated environmental justice impacts would occur. In this region the ownership and crews of the catcher vessels are assumed to tend to mirror the demographic composition of adult male populations of the home port communities, so local fleets from at least a few communities in this region are likely to be owned and crewed by Alaska Native residents. Under this FMP, the total value of catcher vessel operations would appear to decrease as would corresponding labor income and employment; therefore, a potential environmental justice impact would result, but this is likely to be at least in part an artifact of the output model distribution rather than an impact that would be high and adverse.

Kodiak Island. As described in existing conditions, groundfish processing and catcher vessel activity in this region is highly concentrated in the City of Kodiak. Although the city is ethnically diverse, it does not have a predominantly Alaska Native population as do some of the groundfish fishing communities in the Alaska Peninsula/Aleutian Islands region. However, as described under existing conditions, the in-region processing workforce is predominantly a minority population. In-region processing employment would increase over baseline conditions by about 134 jobs; therefore, no environmental justice impacts would result. Total in-region groundfish processing value would increase from $81 million to $100 million. Increased in-region processing value would correspond to additional municipal revenue and taxes to the City and the Kodiak Island Borough, but given local and regional demographics, this is not likely to be an environmental justice issue. Ownership and crews of the catcher vessels are assumed to tend to mirror the demographic composition of the adult male population of the City of Kodiak itself, and therefore the local fleet associated population is not likely to be predominately Alaska Native (or comprised of other identified minority populations). Under this FMP, the total value of catcher vessel operations would increase as would corresponding labor income and employment, but given demographic assumptions, this is unlikely to be of any consequence as an environmental justice issue.

Southcentral Alaska. As described in existing conditions, environmental justice concerns are much less salient in this region than in the Alaska Peninsula/Aleutian Islands or Kodiak Island regions. The communities most directly engaged in the groundfish fishery, particularly with respect to the processing sector, are largely non-Native communities, and have relatively large populations and diversified economic opportunities. Further, there is a relatively low level of groundfish related processing employment overall. Catcher vessel related employment is assumed to mirror community demographics, and thus it is unlikely that environmental justice issues will be associated with any employment change. In general, under this FMP overall combined direct, indirect, and induced labor income and FTEs increase, but this change is not linked to environmental justice concerns. Similarly, processing value increases; however catcher vessel associated values decrease, but these changes are not tied to environmental justice concerns.

Southeast Alaska. The situation in this region is similar to that seen in southcentral Alaska, with the possible exception of the community of Yakutat, which is more predominantly Alaska Native than the other regionally important groundfish communities. Data confidentiality constraints preclude a discussion of Yakutat alone, but otherwise overall environmental justice concerns appear not to apply in this region. In general, under this FMP overall combined direct, indirect, and induced labor income and FTEs increase, but this change is not linked to environmental justice concerns. Similarly, processing value increases as do analogous catcher vessel associated values, but this change is not associated with environmental justice concerns.

Washington Inland Waters. The greater Seattle area is the regional community most engaged in the groundfish fishery, and it is a demographically and economically diverse major metropolitan area. In-region processing does not occur, and while a number of other communities in the region outside of Seattle are home to groundfish catcher vessels, there is no indication that these communities or the associated vessel owners and crew are comprised of minority populations. As described in existing conditions, environmental justice concerns for this region are concentrated in the at-sea processing sector, due to the predominance of minority representation within this workforce. Under this FMP, at-sea processing labor income and FTEs increase (if by less than significant amounts), so there are no environmental justice impacts associated with this change.

Oregon Coast. This region is engaged in the commercial groundfish fishery through its regionally owned catcher vessel fleet. This fleet is concentrated in a limited number of communities in the region, and there is no indication that these are minority communities, nor is there any indication that the population directly associated with fleet ownership and/or crew is either a minority population or a low-income population. In general, under this FMP overall combined direct, indirect, and induced labor income and FTEs increase, as do catcher vessel related values, but these changes are not linked to environmental justice concerns.

CDQ Region. The CDQ region is predominately comprised of Alaska Native communities that have relatively limited commercial economic opportunities, so any adverse impacts to this program and region are likely to involve environmental justice concerns. As described above, the CDQ program and region would not experience adverse impacts under this FMP, therefore no associated environmental justice impacts are likely to result.

Subsistence. Subsistence activities typically disproportionately involve Alaska Native communities and populations, and in a few cases (such as Steller sea lion subsistence) exclusively involve Alaska Native individuals and groups. As a result, adverse impacts to subsistence pursuits are likely to involve environmental justice concerns. Subsistence activities where there are potential environmental justice issues include the following:

- Harvest of groundfish (which occurs to some extent in all four Alaska regions), Steller sea lion (primarily and activity in the Alaska Peninsula/Aleutian Islands region), and salmon (primarily an issue in western Alaska, where poor runs have adversely affected subsistence harvests).

- The loss of income from fishing that would otherwise be directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would otherwise be available for joint production (which occurs to some extent in all four Alaska regions).

While there are some concerns about the effect of the groundfish fishery on Steller sea lions and salmon bycatch, it has been determined that fishing under FMP 1 is not having a significantly adverse contribution to Steller Sea lion and salmon populations and their availability for subsistence harvest. Significantly adverse direct/indirect impacts to subsistence activities are not foreseen under this FMP, therefore no associated Environmental Justice impacts are anticipated.

Cumulative Effects of FMP 1

The predicted direct and indirect effects of the groundfish fishery under the FMP 1 are described above. The past/present effects on Environmental Justice issues are described in Section 3.9.6. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. The representative indicators used in this analysis is the same as that used in the direct/indirect analysis (Table 4.5-78).

Environmental Justice

- **Direct/Indirect Effects.** Under FMP 1, insignificant effects to baseline Environmental Justice issues are anticipated.

- **Persistent Past Effects.** Persistent past effects include the following events and activities. Enactment of local and state taxes and the Fisheries Resource Landing Tax have increased revenues to many Alaskan communities, including those with significant Alaska Native populations. The initiation of the MSA phased out foreign fishing activities, adversely effected salmon populations on the high seas. The establishment of the CDQ program encouraged investment by Alaska residents from predominantly Alaska Native communities in groundfish fisheries, in order to promote economic development. Commercial fishing has become a dominant source of employment and income for many Native Alaskans.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. Other fisheries, other economic development activities, and long-term climate change and regime shift have the potential to adversely or beneficially affect Environmental Justice issues. Other federal and state fisheries allocate quota, to CDQ groups, provide opportunities for non-CDQ Alaska Natives to participate in fish harvesting and processing, and provide tax revenue to communities in Alaska with substantial Alaska Native populations. Changes in economic conditions in these other Alaska fisheries (e.g., crab fisheries closures and reduced salmon fisheries) could impact Environmental Justice issues in several ways in combination with changes in relative allowable catch, value of groundfish and associated revenues to Alaskan Native communities.

Environmental Justice issues could be impacted by decreases in other economic activities that create opportunities for employment and income for Alaska Natives. Reductions in construction of public and private infrastructure, and limited economic development activities in many small coastal communities can adversely affect Alaska Natives.

Reductions in state and local revenue may adversely affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire debt service. When these communities have significant Alaska Native populations, adverse Environmental Justice effects may result.

Fluctuations in natural conditions, such as short-term and long-term climate change, could adversely affect availability of fish and wildlife for Alaska Native subsistence use and commercial fishing.

- **Cumulative Effects.** Under FMP 1, an insignificant cumulative effect is identified for Environmental Justice, with the exception of the Alaska Peninsula/Aleutian Islands. The direct/indirect effects on income for subsistence pursuits, and participation and employment opportunities for Alaska Natives in the fishery generally increase. Reductions in revenues to local communities could potentially effect Environmental Justice issues, but not of a magnitude to be significant. Effects from bycatch of salmon and Steller sea lion subsistence activities are cumulatively insignificant. The external effects from the crab closures and downturn in the salmon industry and reductions in employment funded by public revenue, and reductions in revenue to Alaskan Native communities are adverse, primarily in the Alaska Peninsula/Aleutian Islands, where cumulative effects are conditionally significant adverse for Environmental Justice issues.

4.5.9.6 Market Channels and Benefits to U.S. Consumers

The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described below. The past/present effects on market channels and benefits to U.S. consumers are described in Section 3.9 (Table 3.9-127) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicator used in this analysis is benefits to U.S. consumers (Table 4.5-79).

Direct/Indirect Effects of FMP 1

FMP 1 is not expected to have a significant effect on benefits to U.S. consumers of groundfish products relative to the comparative baseline. Under FMP 1 the BSAI and GOA groundfish fisheries are expected to continue to provide high and relatively stable levels of seafood products to domestic and foreign markets. An estimate of the final market value of BSAI and GOA seafood products is not available; however, it would be substantially greater than $1.5 billion, the projected 5-year mean of the total wholesale product value of BSAI and GOA groundfish after primary processing under FMP 1. This wholesale product value mean is higher than the comparative baseline, but the increase is not significant.

Cumulative Effects of FMP 1

For a summary of the direct/indirect and cumulative ratings see Table 4.5-79.

Market Channels and Benefits to U.S. Consumers

- **Direct/Indirect Effects.** Under this FMP, increases in benefits to U.S. consumers of groundfish products are expected to occur, but are insignificant.

- **Persistent Past Effects.** These effects on benefits to U.S. consumers of groundfish products include: Alaska Seafood Marketing Institute product promotion activities, research and public awareness regarding the health benefits of seafood consumption, aquaculture development increasing overall availability and demand for seafood products, and changes in processing technology increasing seafood quality.

- **Reasonably Foreseeable Future External Effects.** Other fisheries are adversely or beneficially contributing to market channels and benefits to U.S. consumers of groundfish products. Other fisheries provide relatively stable levels of seafood products to domestic and foreign markets; the supply of fish products could be influenced by competition in markets; foreign fisheries are being over fished; and there has been an increasing trend in domestic seafood consumption. Long-term climate change and regime shifts have the potential to adversely affect the market channels and benefits to U.S. consumers of groundfish products due to the natural fluctuations in groundfish stocks.

- **Cumulative Effects.** Under FMP 1, a cumulative effect is identified for benefits to U.S. consumers of groundfish products, and the effect is judged to be insignificant. The external impacts of other fisheries have the potential to contribute adversely or beneficially to the U.S. consumers of groundfish products and the groundfish market channels. However, the wholesale groundfish product value in conjunction with products from other fisheries is not expected to change benefits to U.S. consumers. The long-term climate change and regime shifts could adversely effect availability for market channels due to the natural fluctuations in groundfish stocks. Cumulative effects under FMP 1 are considered to be insignificant.

4.5.9.7 The Value of the Bering Sea and Gulf of Alaska Marine Ecosystems (including Non-Consumptive and Non-Use Benefits) Alternative 1 Analysis

The predicted direct and indirect effects of the groundfish fishery under FMP 1 are described below. Benefits derived from marine ecosystems and associated species are used as a surrogate to evaluate non-consumptive and non-use benefits. The past/present effects on non-consumptive and non-use benefits to the U.S. general public are described in Section 3.9 and below (Table 3.9-127). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicators used in this analysis include the benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits) (Table 4.5-80).

Direct/Indirect Effects of FMP 1

FMP 1 is predicted to have no significant effects on the level of benefits the Bering Sea and GOA marine ecosystems and associated species provide relative to the comparative baseline. These findings are based on the assessment of the direct and indirect effects of FMP 1 on the environment with respect to the ecosystem issues of predator-prey relationships, energy flow and balance, and diversity. This assessment of ecosystem effects is presented in Section 4.5.10 of this Programmatic SEIS.

The comparative baseline for the benefits that humans derive from the Bering Sea and GOA marine ecosystems is described in Section 3.9.7. To summarize this section, these marine ecosystems and species associated with them provide a broad range of benefits to the American public. Some of the goods and services these ecosystems produce are not exchanged in normal market transactions but have value nonetheless. While there are difficulties in estimating the value the public places on protecting ecological conditions, Section 3.9.7 provides a qualitative discussion of possible benefits provided by the Bering Sea and GOA marine ecosystems. In addition to supporting commercial fisheries, these ecosystems support an array of recreational fishing and subsistence activities as well as non-consumptive activities such as wildlife viewing. Furthermore, some people may not directly interact with the Bering Sea and GOA marine ecosystems and the various species associated with them, but may derive satisfaction from knowing that the structure and function of these ecosystems are protected.

The focus in this analysis is on the direct and indirect effects of the alternatives on ecosystem benefits other than those that accrue to members of society who make a living harvesting, processing and distributing BSAI and GOA groundfish products or who purchase and consume these products. The direct and indirect effects of the alternatives on firms and communities that derive value from the commercial harvest and processing of groundfish are described elsewhere in the Programmatic SEIS. Similarly, the effects of the alternatives on consumers of groundfish products are discussed in a separate section of the Programmatic SEIS.

The value people assign to those marine ecosystem benefits that are unrelated to commercial groundfish fisheries are thought to be considerable. For example, the value of protecting the Steller sea lion alone may be substantial. As discussed in Section 3.9.7, a contingent valuation study suggests that there is a significant willingness to pay on the part of the American public for an expanded federal Steller sea lion recovery program. At this time, however, there is insufficient information to provide a comprehensive measure of the benefits derived from these ecosystems and the various species associated with them.

FMP 1 would maintain current management measures that mitigate the adverse effects of the groundfish fisheries on the Bering Sea and GOA marine ecosystems and associated species. These measures include a network of spatial/temporal closed areas that disperse fisheries geographically and seasonally, a prohibition on the use of non-pelagic trawl gear to fish for pollock in the BSAI, bycatch reduction measures such as the full retention requirement for Pacific cod and pollock, and measures to reduce the incidental catch of seabirds. Furthermore, as discussed in Section 4.5.10, FMP 1 is not expected to result in a significant change in the quantitative measures of any indicators of fishing impacts on marine ecosystems relative to the baseline. Consequently, the change in the level of benefits these ecosystems provide is not expected to be significant.

Cumulative Effects of FMP 1

For a summary of the direct/indirect and cumulative ratings please refer to Table 4.5-80.

Benefits Derived from Marine Ecosystems and Associated Species

- **Direct/Indirect Effects.** Under this FMP the adverse effects that the Alaska groundfish fishery could have on marine ecosystems are increased. FMP 1 is predicted to have a conditionally significant adverse impact on the levels of some of the benefits these ecosystems and the associated species they generate.

- **Persistent Past Effects.** Persistent past effects on benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits) include the following: an increase in public awareness of marine ecosystems (e.g., BSAI and GOA marine ecosystems) and associated endangered species (e.g., Steller sea lions); increased participation in recreational fishing and eco-tourism activities; and public perception associated with lawsuits challenging NOAA Fisheries for failing to meet the requirements of the Endangered Species Act in its management of Alaska groundfish fisheries. These persistent past effects drive the public to value the marine ecosystem and associated species and the public derives satisfaction from knowing that the structure and function of these ecosystems are protected.

- **Reasonably Foreseeable Future External Effects.** Other fisheries are adversely contributing to benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits). Fishing levels in other domestic and foreign fisheries may be affecting the productivity of the marine ecosystem. Long-term climate change and regime shift has the potential to adversely affect the benefits the public derives from marine ecosystems and associated species due to the natural fluctuations in groundfish stocks.

- **Cumulative Effects.** Under FMP 1, a cumulative effect is identified for the benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits), and the effect is judged to be conditionally significant adverse. The external impacts of other fisheries have the potential to contribute adversely to the benefits the public derives from marine ecosystems and associated species. Current fisheries management practices could continue the introduction of non-native species; changes in pelagic forage availability; removal of top predators (potential for seabird by-catch and subsistence harvests of marine mammals); and increased risk of changes in species, functional, and structural habitat diversity for the ecosystem. Long-term climate changes and regime shifts, in combination with fisheries-related pressures, could adversely affect species diversity due to the natural fluctuations in groundfish stocks.

4.5.10 Ecosystem Alternative 1 Analysis

Ecosystems are populations (consisting of single species) and communities (consisting of two or more species) of interacting organisms and their physical environment that form a functional unit with a characteristic trophic structure (food web) and material cycles (movement of mass and energy among the groups). The following analyses of potential direct, indirect, and cumulative effects of FMP 1 apply to the BSAI and GOA ecosystems. Where available information allows, each ecosystem is addressed separately. In most cases, however, information is insufficient to allow individual consideration, and the two ecosystems are treated as a single entity.

The analyses of the alternatives examine three major factors through which commercial fishing can typically affect ecosystem characteristics:

1. Predator-prey relationships.

2. Energy flow and balance.

3. Diversity.

Within these three categories, ten indicators have been selected to allow assessments of the potential future direct, indirect, and cumulative effects of the alternatives:

To assess effects on predator-prey relationships:

1. **Change in pelagic forage availability.** This is a change in the availability of fish such as walleye pollock, Atka mackerel, herring, and other species that serve as food for top predators such as seabirds and marine mammals.

2. **Spatial and temporal concentration of fishery impact on forage.** This is the pattern in space and time of the commercial fishing effort.

3. **Removal of top predators.** This is a decrease in the number of top-predator fish (e.g., Pacific halibut, arrowtooth flounder), seabirds, or marine mammals in the ecosystem, either through direct removal (e.g., targeted catch, bycatch, subsistence harvest) or indirect biological pathways (e.g., decline in reproductive success).

4. **Introduction of non-native species.** This is the establishment of new populations of plants or animals that originate in other marine ecosystems foreign to the BSAI or GOA. In other parts of the world, such as the Great Lakes, introduced species have resulted in major changes to ecosystem characteristics, almost always considered undesirable for biological and economic reasons.

To assess effects on energy flow and balance:

5. **Energy removal.** This is a decrease in the total amount of energy in the ecosystem that is available as nutrients for living organisms.

6. **Energy redirection.** This is a change in the pattern of energy flow within the ecosystem. For example, a shift in energy from one part of the food web to another.

To assess effects on diversity:

7. **Change in species diversity.** This is an increase or decrease in the number of different species in the ecosystem.

8. **Change in functional (trophic) diversity.** This is a change in the variety of species that make up a trophic guild, that is, a group of species that obtain food in similar ways.

9. **Change in functional (structural habitat) diversity.** This is a change in the variety of organisms, such as corals, that grow in ways that provide structures for other species to live in and around. Many of the species providing structural habitat are bottom-dwellers.

10. **Change in genetic diversity.** This is a change in the variety of genes within a population (single species). In general, greater genetic diversity bestows a greater ability of the population to deal with environmental stressors such as changes in food availability, water quality, or climate.

Direct/Indirect Effects FMP 1 on Ecosystems

The following sections discuss the potential direct/indirect effects of FMP 1 on the ten indicators noted above.

Predator-Prey Relationships

Pelagic forage availability is assessed by evaluating population trends in pelagic forage biomass for species with age-structured population models. This includes walleye pollock in the GOA (Figure H.4-17 of Appendix H) and Bering Sea walleye pollock and Aleutian Islands Atka mackerel (Figure H.4-18 of Appendix H). Trends in bycatch of other forage species (herring, squid, and forage species group) in the groundfish fisheries are used as a measure of the potential impact on those groups in the BSAI and GOA (Figure H.4-19 and Figure H.4-20 of Appendix H). Table 4.5-81 summarizes the average values from 2003-2008 for these measures and the percent change in the average values from the comparative baseline levels. Under FMP 1, pelagic forage biomass in the BSAI (Bering Sea walleye pollock + Aleutian Islands Atka mackerel) would decline by about 10 percent from the baseline, and pelagic forage biomass (specifically, walleye pollock) in the GOA would increase by about 50 percent over the baseline. Twenty-year biomass projections show similar trends. Average biomass would remain within the bounds of estimated biomass that occurred historically before a target fishery emerged. Bycatch of other forage species would increase by over 75 percent in the BSAI and decline by about 5 percent in the GOA. The projected absolute quantity of bycatch in each region is relatively small (2,930 mt and 250 mt, respectively). Estimates of forage biomass from food web models of the EBS suggest that this bycatch would be a small proportion of the total forage biomass (Aydin *et al.* 2002). However, the lack of population-level assessments for some species in the forage species group means that corresponding species-level effects are unknown. On the basis of this analysis, FMP 1 is determined to have an insignificant effect on the BSAI and GOA ecosystems with respect to pelagic forage availability.

Spatial and Temporal Concentration of Fishery Impact on Forage

Spatial and temporal concentration of fishery impact on forage species is assessed qualitatively by considering the potential for the alternatives to concentrate fishing on forage species in regions utilized by predators that are tied to land, such as pinnipeds and breeding seabirds. Additionally, possibility for concentration of fishing effort to result in an ESA listing or lack of recovery to an ESA-listed species is also considered. FMP 1 would continue the existing closures around Steller sea lion rookeries, the ban on forage fish, and the spatial and temporal allocation of TAC for pollock and Atka mackerel, resulting in an insignificant effect of the spatial/temporal concentration of the fishery on forage species. Bering Sea pollock fisheries have been showing an increasing catch in northern fur seal foraging habitat in the baseline, and more research is required to evaluate whether the amounts of pollock removed are having a population-level effect on the fur seals.

Removal of Top Predators

Removal of top predators, either through directed fishing or bycatch, is assessed by evaluating the trophic level of the catch relative to trophic levels of the groundfish biomass (Figures H.4-21 through H.4-24 of Appendix H), bycatch levels of sensitive top predator species such as birds and sharks (Figures H.4-25 and H.4-26 of Appendix H), and a qualitative evaluation of the potential for catch levels to cause one or more

top-level predator species to fall below biologically acceptable limits (MSST for groundfish and ESA listing or lack of recovery to an ESA-listed species). Trophic level of the catch in both the BSAI and GOA is a very stable property, changing less than 3 percent on average from the baseline, and trophic levels of the groundfish species for which we have age-structured models, and which dominate the catch, change less than 0.2 percent on average. Similarly, top predator bycatch amounts would increase slightly in the BSAI (+5.9 percent) and decrease slightly, on average, in the GOA (-1.8 percent) relative to the baseline. The absolute values of average catch of these species are estimated to be 715 mt and 1,290 mt in the respective regions under this FMP. The significance threshold for this effect is defined as catch levels high enough to cause the biomass of one or more top level predator species to fall below minimum biologically acceptable limits (MSST for target species and ESA listing or lack of recovery to an ESA-listed species) (Table 4.1-7).

The above indicators result in no change to the established baseline condition. The baseline determination concludes that historical whaling has resulted in low present-day abundance of whale species in the North Pacific Ocean. FMP 1 would not further impair the recovery of these species through direct takes. Similarly, levels of seabird and pinniped bycatch in groundfish fisheries in this alternative would not lead to an ESA listing for any of those populations or prevent any of the species from recovery under the ESA. Sections 4.5.7 and 4.5.8 discuss the effects of groundfish fishery direct takes on specific seabird and marine mammal populations. The effect of shark bycatch on shark populations is unknown at present, and research directed at better assessing population levels of these sensitive (late maturing, low fecundity, low natural mortality) species is needed to identify the potential impacts of groundfish fisheries on this resource. Section 4.5.3 discusses current trends in shark populations as considered in the other species category. Stability in trophic level of the catch is indicative of little effect of the fishery on top predators within the target and PSC species groups (Greenland turbot, arrowtooth flounder, sablefish, Pacific cod, and Pacific halibut). See Section 4.5.1 for details on these target species and Section 4.5.2 for Pacific halibut. Overall, this alternative would have insignificant and unknown effects on top predators.

Introduction of Non-Native Species

The introduction of non-native species through ballast water exchange and hull-fouling organism release from fishing vessels could potentially disrupt the Alaskan marine food web structure. Recent work done primarily in Port Valdez and PWS shows that biological introductions of non-indigenous species has occurred, although these introductions cannot be ascribed to a particular vessel type such as oil tankers or fishing vessels (Hines and Ruiz 2000). There have been 24 species of non-indigenous plants and animals documented in Alaskan waters, primarily in shallow-water marine and estuarine ecosystems, with 15 species recorded in PWS, where most of the research has been conducted. One example of a likely introduction is the predatory seastar (*Asterias amurensis*), which is found in other areas of Alaska but has not previously been found in Cook Inlet. These predators have the potential to have a major impact on benthic communities. However, impacts from these introductions have not yet been observed in Alaskan waters. It is possible that most of these introductions were from tankers or other ships that have large amounts of ballast exchange. However, exchange via fishery vessels that take on ballast from areas where invasive species have already been established and that transit in Alaskan inshore waters has been identified as a threat in a recently developed State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002). The state management plan emphasizes the seriousness of non-native introductions, with respect both to biological changes and resulting economic impacts. Therefore, the potential for one or more non-native species to establish viable Alaskan populations is evaluated as having a conditionally significant adverse effect on the comparative baseline.

Total groundfish catch levels are used as an indicator of potential changes in the amount of these releases via groundfish fishery vessels (Figure H.4-27 and Figure H.4-28 of Appendix H, Table 4.5-81). Under FMP 1, total catch would decrease by less than one percent in the BSAI and increase by about 12 percent in the GOA relative to the baseline. These projected catch levels are similar to recent catches in these areas, indicating a similar level of effort and thus a similar potential for fishing vessel introduction of non-native species through ballast water exchange or hull-fouling organism release. Under FMP 1, therefore, there would be an insignificant change from the baseline with respect to the potential for introducing non-native species from fishing vessels and gear.

Energy Flow and Balance

As discussed in Section 3.10, fishing may alter the amount and flow of energy in an ecosystem by removing energy and altering energetic pathways through the return of discards and fish processing offal back into the sea. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system. Baseline energy removals, in the form of total catch, were less than one percent of the total system energy as determined by mass-balance modeling of the system and were determined to have an insignificant impact on the ecosystem. Total retained catch removals under FMP 1 would decrease by less than one percent in the BSAI and increase by about 20 percent in the GOA relative to the baseline (Table 4.5-81). These are still less than one percent of the total system energy as estimated from mass-balance modeling for the eastern Bering Sea. Therefore, impacts on energy removals are determined to be insignificant with respect to the potential for producing changes in system biomass, respiration, production, or energy cycling outside the range of natural variability (Table 4.1-7). Further examination of the potential for fishery removals to induce changes in system-level characteristics should be undertaken using present-day ecosystem models of the BSAI and GOA.

Energy re-direction, in the form of discards, disposal of fish processing offal, or unobserved gear-related mortality, can potentially change the natural pathways of energy flow in the system. For example, discards of dead flatfish or small benthic invertebrates might be consumed at the surface by scavenging birds that would normally not have access to those sources of energy. Animals damaged when passing through the meshes of trawls may later die and be consumed by scavengers. Bottom trawls can expose benthic organisms, making them more vulnerable to predation. Discards and offal production can cause local enrichment and change species composition or water quality if discards or offal returns are concentrated locally. These effects were determined to be insignificant at the ecosystem level in the baseline. Trends in total discards (Table 4.5-81, Figure H.4-29 and Figure H.4-30 of Appendix H) under FMP 1 show about a 5 percent increase in the BSAI and a 15 percent decrease in the GOA relative to the baseline. This amount of change is determined to be small in comparison to historical amounts of discards and is determined to have an insignificant potential effect on ecosystem-level energy cycling characteristics.

Change in Species Diversity

Fishing can alter different measures of diversity. Species-level diversity, or the number of species, can be altered if fishing removes a species from the system. Fishing can alter functional diversity from a trophic standpoint if it selectively removes or depletes a trophic guild member, thus changing the distribution of biomass within a trophic guild. Functional diversity from a structural habitat standpoint can be altered if fishing methods such as bottom trawling remove or deplete organisms such as corals, sea anemones, or sponges that provide structural habitat for other species. Fishing can alter genetic diversity by selectively

removing faster growing fish or removing spawning aggregations that might have genetic characteristics that are different from other spawning aggregations. Large, old fishes may be more heterozygous than younger fish (i.e., have more genetic differences or diversity) and some stock structures may have a genetic component (see review in Jennings and Kaiser 1998). Consequently, one would expect a decline in genetic diversity to result from heavy exploitation of a fishery.

Significance thresholds for effects of fishing on species diversity are defined as catch removals high enough to cause the biomass of one or more species (target or non-target) to fall below, or to be kept from recovering from levels already below, minimum biologically acceptable limits (MSST for target species, ESA listing for non-target) (Table 4.1-7). Indicators of significance are population levels of target and non-target species relative to MSST or ESA listing thresholds, linked to fishing removals. Bycatch amounts of sensitive (low population turnover rates) groups that lack population estimates (skates, sharks, grenadiers, and sessile invertebrates, such as corals, inhabiting Habitat Areas of Particular Concern, or HAPC) may also indicate potential for fishing impact on these species (Table 4.5-81, Figure H.4-31 and Figure H.4-32 of Appendix H). Closed areas also provide protection, particularly to less-mobile species like HAPC biota, so the amount of area closures across habitat types can indicate the degree of species-level diversity protection. Baseline determinations of insignificance were concluded for most of these indicators, and were unknown for skates and sharks.

Under FMP 1, closed areas would remain the same and bycatch of HAPC biota would increase by about 10 percent in the BSAI and decrease by almost 30 percent in the GOA. Although it is unknown whether bycatch amounts of HAPC biota would be at levels high enough to bring these species to minimum population thresholds, area closures would likely be sufficient to prevent species removal for these sessile animals. Catch amounts of target species, prohibited species, seabirds, and marine mammals would be insufficient to bring species within these groups below minimum population thresholds. It is unknown whether bycatch amounts of skates, sharks and grenadiers would be at levels high enough to bring species within these groups to minimum population thresholds. Further research on the species-level distribution, abundance trends, and life history parameters of these species is necessary to assess the risk of their falling below minimum population abundance thresholds. Although forage species population levels are not known, their relatively high turnover rates and the ban on forage fish fisheries in this alternative is considered sufficient to protect them from falling below minimum biologically acceptable limits. However, some of the species in the forage group are not well studied (such as stichaeids, gunnels) and life-history parameter determination should be a priority in the future to better assess the risk of their falling below acceptable population thresholds of abundance.

On the basis of the preceding considerations, we determine that FMP 1 would have insignificant and unknown effects on species diversity. More years of survey data and life history parameter determination for skates, sharks and grenadier species may better define population trends and the need for further protection. See Sections 4.5.1 (target species), 4.5.2 (prohibited species), 4.5.3 (other species), 4.5.4 (forage species), 4.5.5 (non-specified species), 4.5.6 (habitat), 4.5.7 (seabirds) and 4.5.8 (marine mammals) for more detailed analyses of the potential for fishery removals to affect minimum population thresholds and species diversity for each of these groups.

Change in Functional Diversity

Functional (either trophic or structural habitat) diversity can be altered through fishing if fishing selectively removes one member of a functional guild, which may result in increases in other guild members. A

functional guild is a group of species that use resources within the ecosystem in similar ways. Significance thresholds are defined as catch removals high enough to cause a change in functional diversity outside the range of natural variability observed for the system. Indicators of the possible magnitude of effects include qualitative evaluation of guild or size diversity changes relative to fishery removals, bottom gear effort changes that would provide a measure of benthic guild disturbance, and bycatch amounts of HAPC biota, a structural habitat guild. Under FMP 1, the species composition and amounts of removals, and the bottom gear effort and bycatch amounts of HAPC biota (Table 4.5-82, Figure H.4-31 and Figure H.4-32 of Appendix H), would be relatively similar to the comparative baseline, in which fishing impacts on functional guild diversity were determined to be insignificant for trophic diversity and structural habitat diversity.

Members of the HAPC biota guild serve important functional roles, known only in a preliminary way, to provide fish and invertebrates with structural habitat and refuge from predation. The abundance of these structural species necessary to provide protection is not known, and it may be important to retain populations of these organisms that are well distributed spatially in order to fulfill their functional role. Some of these organisms have life-history traits that make them very sensitive to fishing removals. The long-lived nature of corals, in particular, makes them susceptible to permanent eradication in fished areas. Therefore, it is important to evaluate the spatial distribution of areas closed to bottom fishing with respect to coral distribution to ensure a broad spatial distribution that would be necessary for them to fulfill their functional role. Present-day Steller sea lion trawl closures are spread throughout the Aleutian chain, but these closures may be more inshore than most of the coral. For this reason, the areas closed to trawling in this alternative may not be sufficient to provide additional protection beyond the baseline for these sensitive organisms.

Change in Genetic Diversity

Genetic diversity can be affected by fishing through heavy exploitation of certain spawning aggregations or systematic targeting of older age classes that tend to have greater genetic diversity. Genetic diversity has not been well assessed in the comparative baseline and is unknown for many species. On the basis of evidence from other, more highly fished systems, the degree of spatial/temporal management of TAC, and the lack of target species falling below MSST due to a decline in genetic diversity, it is concluded that effects of fishing on genetic diversity are insignificant or unknown. Under FMP 1, no target species would fall below MSST and the same spatial and temporal management of TAC and similar catch and selectivity patterns in the fisheries would apply, so we would expect an insignificant impact of fishing on genetic diversity. However, because actual genetic diversity remains unknown for most species, the potential direct/indirect effects of fishing on genetic diversity are also largely unknown.

Cumulative Effects Analysis of FMP 1 on Ecosystems

The following sections briefly discuss the potential cumulative effects of FMP 1 on the ten ecosystem indicators explained in Section 4.5.10. These potential cumulative effects are summarized in Table 4.5-82. Data and calculations supporting the energy removal analyses for the alternatives are presented in Section 4.5.11.

Change in Pelagic Forage Availability

- **Direct/Indirect Effects.** The direct/indirect effects of FMP 1 on pelagic forage availability are expected to be insignificant. The BSAI pelagic forage biomass, as estimated by Bering Sea pollock and Aleutian Islands Atka mackerel, is predicted to decrease by 9.2 percent, and the total biomass

of GOA pollock is predicted to increase by 50.9 percent. These fishery-induced changes would be within the natural level of abundance or variability for prey species relative to predator demands (Table 4.1-7).

- **Persistent Past Effects.** Past effects of forage fish bycatch by the BSAI pollock and GOA rockfish domestic fisheries, and targeted domestic catches of pollock and Atka mackerel, are likely to have affected forage fish populations in ways that may persist into the present and future (Section 3.10.1.4). For example, before full observer coverage began in the late 1980s, the herring bycatch in BSAI trawl fisheries, principally those targeting pollock, may have been 8,000 to 10,000 tons (7,300 to 9,100 mt) per year (ADF&G 2003a). Past fishing pressures may also exert a persistent effect on these species, particularly on GOA capelin populations (Section 3.10.3). From about 1925 to 1941, Alaska herring harvests for oil and meal ranged from about 50,000 to 150,000 mt per year, and a large foreign herring fishery removed 30,000 to 150,000 mt per year during the 1960s and 1970s (ADF&G 2003a). Past climatic changes, including inter-decadal oscillations and ENSO events, have been shown to affect forage fish populations (Section 3.10.1.5), and these effects may still exist.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska directed herring fishery will remove an annual increment of pelagic forage biomass. Herring harvested for sac roe have averaged about 50,000 tons (45,500 mt) per year, and the commercial catch of herring for bait averages about 8,000 tons (7,300 mt) per year. The State of Alaska manages herring fisheries on a sustainable basis and has established a maximum exploitation rate (fraction of the spawning population removed by the fishery) of 20 percent. Fisheries are closed if stock size falls below the threshold level (MSST). Lower exploitation rates are applied when herring stocks decline to near-threshold levels (ADF&G 2003a). This management approach is expected to continue for the indefinite future. Subsistence harvests will continue to remove an increment of pelagic forage biomass each year. Because the State of Alaska has not established annual harvest assessment programs for subsistence fisheries other than salmon, there is little monitoring of subsistence fish harvests, and annual statewide catch data are not compiled (ADF&G 2001). Relative to the BSAI and GOA groundfish fisheries, however, the additional contribution of subsistence fisheries to the annual removal of pelagic forage biomass is likely to be very small. The Exxon Valdez disaster of 1989 suggests that a large petroleum spill coinciding in space and time with herring or capelin spawning, would most likely produce population declines and other adverse effects on pelagic forage species (such as eulachon, which spawn on beaches). Finally, future climate change, especially a regime shift, would be likely to affect the productivity, and thereby the population sizes, of pelagic forage species (Section 3.10.1.5).

- **Cumulative Effects.** A conditionally significant adverse cumulative effect on pelagic forage availability would occur in the event of a large petroleum spill. The conditions under which this effect would be significant relate to the areas affected and seasonal timing of the spill. If these events coincide with spawning locations and times, a significantly adverse cumulative effect on pelagic forage availability would most likely result. Additive or interactive contributions from State of Alaska commercial fisheries and subsistence fish harvests are not expected to be significant. A future climatic regime shift would not appreciably offset, but could intensify, this potential cumulative effect if the productivity of pelagic forage species is reduced.

Spatial/Temporal Concentration of Fishery Impact on Forage

- **Direct/Indirect Effects.** The direct/indirect effects of the spatial/temporal concentration of fishing effort under FMP 1 on pelagic forage availability are expected to be insignificant. FMP 1 would continue the existing closures around Steller sea lion rookeries, the ban on forage fish, and the spatial/temporal allocation of TAC of pollock and Atka mackerel, which have been determined to result in an insignificant impact on the spatial/temporal concentrations of fishing efforts on forage species (Section 4.5.11).

- **Persistent Past Effects.** Geographic and seasonal concentrations of past forage fish bycatch from the BSAI pollock and GOA rockfish fisheries, herring bycatch, and targeted catches of pollock and Atka mackerel have affected forage fish populations in ways that may have persisted into the present and future (Section 3.10.1.4). Past herring fisheries have followed a stable pattern of timing and location dictated by the spawning behavior of the fish (ADF&G 2003a). Past climatic changes, including inter-decadal oscillations and ENSO events, have been shown to affect recruitment rates and distribution patterns of forage fish populations (Section 3.10.1.5). Such effects may be exerting a persistent effect on forage fish populations, although evidence is not sufficient to allow quantification.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska directed herring fishery will exert fishing pressures on herring and other forage fish populations at particular times and places that could overlap with fishing pressures from the groundfish fisheries. Because the herring fishery is mainly inshore, overlap with the groundfish fishery will more likely be temporal than spatial. Subsistence harvest patterns are not coordinated with commercial fishing effort and will sometimes overlap with spatial/temporal patterns of the groundfish fishery, but the incremental contribution of subsistence to this cumulative effect will continue to be negligible. The Exxon Valdez disaster of 1989 suggests that a large petroleum spill, coinciding in space and time with herring or capelin spawning, would most likely produce population declines, and adverse effects on other pelagic forage species (such as eulachon, which spawn on beaches). Finally, future climate change, especially a regime shift, could alter the spatial/temporal distributions of pelagic forage species in ways that might be synergistic with spatial/temporal concentrations of fishing effort in the BSAI and GOA groundfish fisheries.

- **Cumulative Effects.** A conditionally significant adverse cumulative effect on pelagic forage availability could result in the reasonably foreseeable future, synergistic with the spatial/temporal concentration of the BSAI and/or GOA groundfish fishing effort. The conditions under which this effect could be significant relate to location and timing. If the fishing efforts of State of Alaska directed fisheries, principally for herring, and subsistence fish harvests converge in space and time with a large-scale petroleum spill, forage fish populations could be significantly depressed as to impair the long-term viability of ecologically important top predators such as seabirds and marine mammals (Table 4.1-7). Future climate change, consistent with effects observed in the recent past (Section 3.10.1.5), could alter the spatial/temporal distributions of pelagic forage species in ways that might reduce or intensify this potential cumulative effect.

Removal of Top Predators

- **Direct/Indirect Effects.** The implementation of FMP 1 is predicted to have insignificant effects on top predators such as whales, other marine mammals, seabirds, and top predatory fish species such as Greenland turbot, arrowtooth flounder, sablefish, Pacific cod, and Pacific halibut. This alternative would not impair the continued recovery of whale populations, which are still reduced due to direct take in the past. Levels of seabird and marine mammal bycatch in the groundfish fisheries would not lead to listing any of these species or preventing recovery under the ESA. Because there is little available information on shark bycatch and current population status, the direct/indirect effects of this alternative on sharks are rated as unknown.

- **Persistent Past Effects.** Before passage of the MSA in 1976, groundfish fisheries in the BSAI and GOA produced much higher than present bycatch levels of sharks (Sections 3.5.3 and 4.5.3), seabirds (Sections 3.7.1 and 4.5.7), and marine mammals (Sections 3.8 and 4.5.8). Historical whaling, particularly very high mortality levels in the 1960s (Section 3.10.1.3), produced a sustained effect on these slowly reproducing populations that is reflected in the low present-day abundance of whale species in the North Pacific (Section 4.5.8). State of Alaska directed groundfish fisheries, which are small and sustainably regulated, have annually removed top predators such as sablefish and Pacific cod at levels safely above MSST (ADF&G 2003b). These fisheries also produced shark, seabird, and marine mammal bycatch in the past, although quantitative data are lacking on past and current bycatch levels in these fisheries. Past and present groundfish fisheries operating outside of U.S. jurisdiction in the Western Bering Sea have also contributed to the bycatch of top predators, in some cases at high level. Marine mammals continue to be removed for subsistence, although at much lower levels than in the past, and past harvests may have had a sustained effect on some populations that persists today (Section 3.10.1). Finally, there is evidence that past climatic variability may have affected the recruitment and distribution of some top predator fish species (Section 3.10.1.5; Hollowed *et al.* 1998).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery will continue to remove a portion of the Pacific halibut population, a top predator (Section 4.5.2). The current policy is likely to continue in the future, although a modified approach has been proposed to produce a yield similar to the present policy while reducing variations in annual yield due to changes in stock abundance, assessment methods, and estimated removals by other fisheries (Clark and Hare 2003). High levels of seabird bycatch and resulting direct mortality are expected to continue annually from NPO longline fisheries operating outside of the EEZ. Available data and estimates for the annual incidental take of individual bird species by these external fisheries are provided and discussed in Section 3.7. The State of Alaska directed groundfish fisheries will continue to remove targeted top predatory fish species in small numbers relative to the domestic groundfish fisheries in federal waters (ADF&G 2003b). Subsistence harvests of marine mammals will continue with an increasing trend toward co-management by NOAA Fisheries and Alaska Native organizations. The Protected Resources Division of NOAA Fisheries will continue to develop management and conservation programs to ensure that annual subsistence harvests are sustainable (NOAA Fisheries 2003). A large petroleum spill at sea could result in the direct mortality of marine mammals, with mortality levels depending on the location, size, and timing of the spill. Finally, a future climatic regime shift could alter total numbers of top predators in the BSAI and GOA ecosystems by increasing or limiting recruitment.

- **Cumulative Effects.** A conditionally significant adverse cumulative effect on total numbers of top predators could result primarily from continued high levels of seabird bycatch by NPO longline fisheries operating outside the EEZ. Because these external fisheries are generally not managed in conjunction with the BSAI and GOA domestic groundfish fisheries, it is likely that the present high levels of seabird bycatch will continue in the future. The conditions under which this cumulative effect could be significant include the continuation of high external seabird bycatch rates in conjunction with a large petroleum spill, along with incremental removals of top predators by the IPHC longline fishery, State of Alaska directed groundfish fisheries, and subsistence harvests of marine mammals. As determined from recent climatic studies (Section 3.3), a climatic regime shift is probable in the reasonably foreseeable future, and could intensify or reduce the potential cumulative effect by influencing recruitment.

Introduction of Non-Native Species

- **Direct/Indirect Effects.** Under FMP 1, total catch (target and nontarget species) would decrease by less than one percent in the BSAI and increase by about 12 percent in the GOA relative to the baseline (Table 4.5-81). These catch levels indicate that this alternative would maintain about the same potential for fishing-vessel introduction of non-native species through ballast water exchange or release of hull-fouling organisms that currently exists under baseline conditions. Therefore, the direct/indirect effect of FMP 1 on predator-prey relationships through the introduction of exotic species is evaluated as insignificant.

- **Persistent Past Effects.** For decades, the annual arrival of groundfish fishing vessels from ports outside of Alaska has made it possible for non-native species to enter Alaskan waters through the release of ballast water and hull-fouling organisms. Commercial shipping has provided a similar means for the introduction of non-native species (Fay 2002). There have been 24 non-indigenous species of plants and animals documented in Alaskan waters, with 15 of these recorded in PWS, where most of the research has been conducted. Although oil tankers, through the release of ballast water, have been speculated to be the primary source for these introductions, cruise ships and fishing vessels coming from areas where invasive species have already been established have also been identified as a threat in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002). In Washington State and British Columbia, Atlantic salmon (*Salmo salar*) have been farmed in floating saltwater net pens since the late 1980s, and deliberate releases of individual fish considered "non-performing" due to their sub-standard size total hundreds of thousands annually (ADF&G 2002a). Since first reports in 1990, there has been an increasing trend of incidental take of Atlantic salmon in the State of Alaska directed salmon fisheries (GOA), and the first specimen of an Atlantic salmon from the Bering Sea was captured in a bottom trawl south of the Pribilof Islands in 1997 (Brodeur and Busby 1998). Concerns have been expressed regarding the potential effects of introduced Atlantic salmon on native Pacific salmon populations, including diseases and parasites, colonization, interbreeding and hybridization, predation, habitat destruction, and competition, particularly in locations where depressed stocks of Pacific salmon species provide a potential niche for the Atlantic species (Brodeur and Busby 1998, ADF&G 2002a). In the past, Alaska's northern climate, geographic isolation, and small human population, among other factors, may have prevented the establishment of viable populations by non-native species introduced from more temperate regions (Fay 2002).

- **Reasonably Foreseeable Future External Effects.** IPHC longline fishery vessels, international longline and groundfish fleets operating outside the EEZ, and vessels participating in State of Alaska directed fisheries will continue to be potential sources of exotic introductions in the future. In addition, commercial shipping, including cruise ships and barges and tankers with high-volume ballast water releases, will continue to bring non-native species into Alaskan waters on a recurring basis, maintaining a continuing pressure on indigenous populations (Fay 2002). Escapes and releases of farmed Atlantic salmon from Washington State and British Columbia net-pens might eventually establish runs in GOA coastal streams and rivers. Introduced pathogens and parasites associated with farmed Atlantic or Pacific salmon could infect wild stocks. A future regime shift or long-term warming trend could remove the protection that colder conditions may currently provide against exotic species, allowing viable non-native populations to become established.

- **Cumulative Effects.** When sources of exotic species external to the domestic groundfish industry are considered in combination with FMP 1, it is conceivable that viable populations could eventually become established in the BSAI and/or GOA, producing a conditionally significant adverse cumulative effect (Table 4.1-7). One possible, but unproven, condition for this outcome would be a future climatic regime shift or long-term warming trend that might allow exotic species currently limited by low seawater temperatures to establish viable populations in the BSAI and/or GOA.

Energy Removal

- **Direct/Indirect Effects.** The direct/indirect effects of FMP 1 on energy removal are expected to be insignificant. Baseline energy removals, in the form of total catch, are less than one percent of the total ecosystem energy, as estimated by mass-balance modeling, and were determined to have an insignificant impact on the ecosystem. Total retained catch removals under FMP 1 would decrease by less than one percent in the BSAI and increase by about 20 percent in the GOA relative to the baseline (Table 4.5-81). These are still less than one percent of the total system energy as estimated from mass-balance modeling for the eastern Bering Sea. Therefore, estimated energy removals under FMP 1 would not have the potential to produce changes in system biomass, respiration, production, or energy cycling outside the range of natural variability (Table 4.1-7).

- **Persistent Past Effects.** The domestic groundfish fisheries, State of Alaska commercial fisheries, IPHC longline fisheries, commercial harvests of marine mammals, and subsistence harvests have all removed biomass from the BSAI and GOA ecosystems, either as targeted species or as bycatch, and these removals, in a regulated and mitigated form, continue today (Section 3.10). Aggregate biomass levels removed by unregulated past human activities would have been influenced by climatic effects on overall system productivity, with biomass removals increasing as productivity increased and correspondingly decreasing with climate-related productivity declines.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fisheries, State of Alaska commercial fisheries, subsistence fish harvests, and subsistence marine mammal harvests will continue to remove biomass from the BSAI and GOA ecosystems. The incremental contribution of the combined State of Alaska herring and crab and IPHC halibut fisheries is estimated at about 6 percent of the cumulative biomass removed annually under this alternative (Table 4.5-82). The State of Alaska directed groundfish and subsistence fisheries would remove an additional small increment annually (ADF&G 2003b, 2001). It should be noted that Russian and other fisheries operating in the Western Bering Sea and in international waters of the Central Bering Sea (doughnut hole) will also

remove biomass in the future. However, these regions show sufficient differences from the EBS with respect to production regimes and topographic and hydrographic features and are viewed as only partly comparable systems. Their interactive components with the EBS, where present, have not yet been characterized (Aydin *et al.* 2002).

- **Cumulative Effects.** The implementation of FMP 1 is predicted to have an insignificant cumulative effect on energy removal in the reasonably foreseeable future. The total domestic groundfish catch under this alternative is estimated to remove less than one percent of the total system energy. If the combined total catch of the State of Alaska herring and crab and IPHC halibut fisheries in the future is similar to the 1997-2001 average, the cumulative total catch of these external fisheries plus the BSAI and GOA groundfish fisheries will increase by about 6 percent over the estimated total catch for FMP 1 alone (Table 4.5-82). This additional increment of biomass removal is not considered sufficient to produce a long-term change in system biomass, respiration, production, or energy cycling outside the range of natural variability due to expected energy removals by the BSAI and GOA groundfish fisheries (Table 4.5-82).

Energy Redirection

- **Direct/Indirect Effects.** The direct/indirect effects of FMP 1 on energy redirection are expected to be insignificant. Projected trends in total discards modeled for FMP 1 show about a 5 percent increase in the BSAI and a 15 percent decrease in the GOA (Table 4.5-82). These effects would be small relative to the baseline and would not produce long-term changes in system biomass, respiration, production, or energy cycling outside the range of natural variability due to fishery discarding and offal production practices (Table 4.1-7).

- **Persistent Past Effects.** Because ecosystem energetics is a dynamic process, it is difficult to know whether past changes in energy cycling and in pathways of energy flow in the BSAI and GOA produced effects that still persist. The most far-reaching changes in quantities and geographic patterns of bycatch discards and offal production from both fish and marine mammal harvests came with international agreements, legislation, and regulatory actions in the 1950s through the 1970s, culminating in passage of the MSA in 1976 (Section 3.10.1.3). These corrective actions greatly curtailed the destabilizing levels of energy redirection that reached their peak in the mid-twentieth century from commercial whaling, fur seal harvests, high-seas driftnet fisheries, and the international commercial groundfish and salmon fisheries that existed prior to passage of the MSA. It seems likely, therefore, that under current management practices, quantities and patterns of energy redirection in the BSAI and GOA are much more limited than they were 50 years ago.

- **Reasonably Foreseeable Future External Effects.** Quantities and geographic patterns of bycatch discards and fish processing wastes released into the sea from the IPHC and State of Alaska commercial fisheries and from subsistence harvests are not expected to change substantially in the future. External energy will also enter the system as graywater and refuse released into the sea from commercial freighters, tankers, and cruise ships. The pattern of such disposal at sea is not expected to change much in the future. Finally, future climatic trends have the potential to affect energy cycling in the ecosystem; in particular, a warming trend would be expected to accelerate rates of energy conversion, whereas cooler conditions would tend to have a retarding effect.

- **Cumulative Effects.** The implementation of FMP 1 is predicted to have an insignificant cumulative effect on energy redirection. The cumulative effect of FMP 1, in combination with external sources, is not expected to depart significantly from the comparative baseline condition to produce long-term changes outside the range of natural variability. At the local level, water quality degradation can be expected from the release of fish processing offal into low-energy environments, such as coves and bays, where nutrients from these wastes can concentrate in sheltered waters and alter local patterns of energy cycling. Although this is not an ecosystem-level effect, it is noted as a consequence of commercial fishing that will continue into the future. The discharge of offal from fish processing facilities and of graywater and other refuse from marine vessels into Alaskan waters is regulated through EPA and ADEC permitting programs.

Change n Species Diversity

- **Direct/Indirect Effects.** The expected direct/indirect effects of FMP 1 on species diversity are rated as unknown for skates, sharks, non-specified species and other species and insignificant for other groups. Under FMP 1, catch levels for target species, prohibited species, seabirds, and marine mammals would be insufficient to bring these species below minimum population thresholds. Forage species life history characteristics, along with the ban on initiating a forage fish fishery under this alternative, and maintaining closed areas that provide protection for HAPC biota (for example, corals) would help to prevent these species from falling below minimum population abundance thresholds. Further research will be required to assess whether FMP 1 bycatch levels for skates, sharks, non-specified species and other species, all poorly understood, will reduce species within these groups, thus, resulting in population-level impacts.

- **Persistent Past Effects.** Although the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, the timing of various increases and decreases in species abundance of fish, seabirds, and marine mammals has not shown a consistent correlation with groundfish fishing intensity (Sections 3.10.1.4). With the notable exception of the Steller's sea cow extinction in the 1760s (Section 3.10.1.1), changes in species diversity have not characterized the BSAI and GOA ecosystems. Although no fishing-related species removals have been documented under fisheries management policies in effect during the past 30 years, elasmobranchs (sharks, skates, and rays) are particularly susceptible to removal, and benthic invertebrate species (including HAPC) are susceptible to bottom trawling (Section 3.10.3). Seabirds have been particularly vulnerable to direct mortality as bycatch, but lack of data on seabird population trends prevents analysis of past effects of fisheries management or environmental change (Section 3.7).

As stated in Section 3.10.3, Livingston *et al.* (1999) found that long-term increases and decreases in the abundance of selected BSAI invertebrate, fish, bird, and marine mammal species did not show positive correlations with prey abundance, and cyclic fluctuations in species abundance occurred in both fished and unfished species. It was concluded that in the eastern Bering Sea ecosystem, the trophic level of the harvest increased slightly since the 1950s and stabilized as of 1994, suggesting that the comparative baseline harvest levels are sustainable. These authors also concluded that the fish populations examined are stable. As emphasized in Section 3.10.1.5, evidence is accumulating that physical oceanographic factors, particularly climate, have a controlling influence on biological community composition in the BSAI and GOA. Although commercial fishing has not been largely

implicated in BSAI and GOA ecosystem changes, studies of other ecosystems with much greater fishing pressures indicate that fishing, in combination with climate change, can alter ecosystem species composition and productivity (Jennings and Kaiser 1998, Livingston and Tjelmeland 2000). Assessing the extent to which this has occurred in the BSAI and GOA ecosystems, or may occur in the future, will require further research.

- **Reasonably Foreseeable Future External Effects.** Although past levels of seabird bycatch by the IPHC and State of Alaska fisheries have not been thoroughly or consistently quantified, they are considered substantial and can be expected to continue in the future (Section 3.7). In addition, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, belugas, harbor seals), may deplete numbers to levels near or below biologically acceptable limits. The potential for introduced exotic species to establish viable populations in the BSAI and GOA will also continue. Such exotics may include Atlantic salmon escapes from net-pen farms, invertebrates and plants introduced through ballast water and from ship hulls, and pathogens introduced by Pacific salmon species that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and enable introduced exotics to establish viable populations.

- **Cumulative Effects.** Under FMP 1, a conditionally significant adverse effect on species diversity could result from a high level of seabird bycatch by the IPHC longline fishery, western Bering Sea fisheries, and State of Alaska commercial fisheries, in combination with the BSAI and GOA groundfish fisheries. In addition, one or more introduced exotic species may establish a viable population that could change species diversity in a negative way by competing with native species for food and habitat (Fay 2002). The consistent, sustained concentration of harvest effort on particularly accessible subpopulations of marine mammals from year to year could intensify this potential effect. Finally, climate change has the potential to alter species productivity and distribution, and a long-term warming trend might facilitate the establishment of viable populations by one or more exotic species. Under some combination of these conditions, the biomass of one or more species could fall below, or be kept from recovering from levels already below, minimum biologically acceptable limits (Table 4.1-7).

Change in Functional (Trophic) Diversity

- **Direct/Indirect Effects.** Potential direct/indirect effects on trophic diversity relate to changes in the variety of species within trophic guilds. The greater the diversity of species within guilds, the more resilient the ecosystem is likely to be, because competing species within the same guild can replace or substitute one another in response to environmental stressors, thereby maintaining the structure of the food web. Under FMP 1, the predicted direct/indirect effects of the groundfish fisheries on trophic diversity are rated as insignificant, because they are expected to be similar to the comparative baseline conditions (Table 4.1-7).

- **Persistent Past Effects.** It is considered unlikely that past removals of fish by the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries significantly affected the variety of species within trophic guilds. Livingston *et al.* (1999) found no evidence that groundfish fisheries had caused declines in trophic guild diversity for the groups studied. They also found that past

changes in species diversity within guilds related to increases in a dominant guild member (e.g., pollock, rock sole) rather than to decreases in abundance caused by fishing pressure (Section 3.10.3). Past variations in climate, such as ENSO events, interdecadal oscillations, and regime shifts, may have affected trophic diversity by influencing the productivity and distribution of different species in different ways, thereby altering the relative proportions of species within guilds.

- **Reasonably Foreseeable Future External Effects.** NOAA Fisheries and ADF&G biologists have recently brought attention to the potential for escaped farmed Atlantic salmon to establish viable Alaskan populations in competition with one or more of the five Pacific salmon species (Brodeur and Busby 1998, ADF&G 2002a, Fay 2002). In addition, the concentrated take of marine mammals from the same local subpopulations over a period of years could affect species diversity within piscivore guilds, that is, guilds consisting of fish-eating species. Releases of ballast water and hull-fouling organisms introduced to BSAI and GOA waters from fishing vessels and commercial shipping could also lead to the establishment of viable populations in competition with native species at similar trophic levels (Fay 2002). A climatic regime shift in the future could affect trophic diversity by forcing trends that expand some trophic levels and contract others, and a long-term warming trend could facilitate the establishment of relatively cold-intolerant exotic populations.

- **Cumulative Effects.** The implementation of FMP 1 could produce a conditionally significant adverse effect on trophic diversity. The primary condition for this effect is largely speculative. A climatic regime shift could make a trophic guild containing one or more target species more vulnerable to fishing pressure. A regime shift in the future, similar to well-documented examples that have occurred in the past (Sections 3.3 and 3.10.1.5), could decrease species diversity within a trophic guild by reducing the productivity or shifting the distributional range of one or more member species. If this climatic effect went undetected and without compensatory adjustments to fishing effort, the continued removal of particular target species, especially slow-growing species such as rockfish, could decrease their representation within trophic guilds.

<u>Change in Functional (Structural Habitat) Diversity</u>

- **Direct/Indirect Effects.** The issue of concern with respect to structural habitat diversity is removal, by bottom gear, of HAPC biota such as corals, sea anemones, and other sessile invertebrates that provide physical structures used as habitat by other species, including economically important groundfish species and their prey. In FMP 1, the species composition and amounts of removals, bottom gear effort and bycatch amounts of HAPC biota, and areas closed to trawling relative to coral distribution are relatively similar to the baseline. Therefore, the change from baseline condition that would result from this alternative is evaluated as insignificant with respect to structural habitat diversity. Some of these organisms have physical characteristics and life-history traits that make them sensitive to fishing removals. The very long-lived nature of corals, in particular, makes them susceptible to permanent eradication in fished areas. It is important to ensure that the spatial distribution of areas closed to bottom fishing is broad enough, relative to coral distribution, to allow the corals to fulfill their functional role. Present trawl closures protecting Steller sea lion habitat are spread throughout the Aleutian chain, but these closures may be farther inshore than most of the coral. Because the areas that would be closed to trawling under FMP 1 would be similar to the comparative baseline conditions, they might not be sufficient to provide protection to these sensitive organisms.

- **Persistent Past Effects.** Bottom-trawling by the pre-MSA international groundfish fisheries, groundfish fisheries after passage of the MSA in 1976, and State of Alaska scallop fisheries have all contributed to the damage or depletion of the structural habitat functional guild in past years. Because little is known about the taxonomic structure of benthic communities of the BSAI and GOA, any past effects of trawling and other fishing-related activities on the species diversity of these communities cannot be quantified. Long-term climatic trends may also have influenced HAPC species through effects on their productivity and distribution, but in the absence of data no conclusions can be made.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska-managed scallop fishery employs bottom dredges that will continue to damage or remove structural habitat provided by sessile invertebrates such as corals, sea anemones, and sponges. In addition, a large petroleum spill could contact areas covered by these sensitive bottom-dwelling organisms and damage or kill them. A climatic regime shift could change the mean annual seawater temperature sufficiently to increase or retard the growth of benthic organisms, thereby altering structural habitat diversity.

- **Cumulative Effects.** Direct/indirect effects of FMP 1, rated insignificant, could contribute to a conditionally significant adverse cumulative effect on structural habitat diversity under any of the following three conditions. First, the additive effect of the scallop fishery, employing bottom dredges, could add to the effects of bottom trawling by the groundfish fishery on HAPC biota. Second, a large petroleum spill could also damage these sensitive organisms. Third, a change in seawater temperature resulting from a climatic regime shift in the future could reduce the productivity, and thus the population size and/or distribution of bottom-dwelling invertebrates that provide structural habitat.

Change in Genetic Diversity

- **Direct/Indirect Effects.** If FMP 1 were implemented, no target species would fall below MSST, and spatial/temporal management of TAC, other catch, and selectivity patterns in the fisheries would be similar to the comparative baseline conditions. Consequently, the effect of the groundfish fisheries on genetic diversity would be insignificant under this alternative. However, because genetic diversity remains unknown for most species, the potential direct/indirect effects of fishing are also largely unknown.

- **Persistent Past Effects.** The pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, but data are not available to indicate whether genetic diversity was measurably affected. As discussed in Section 3.10.3, if a fishery concentrates on certain spawning aggregations or on older (larger) age classes of a target species that tend to have greater genetic diversity, then genetic diversity will tend to decline in fished versus unfished systems. It is possible that genetic diversity has already declined in the BSAI and GOA ecosystems, but this cannot be determined in the absence of current conditions. Heavy exploitation of certain spawning aggregations occurred historically (e.g., Bogoslof pollock), but recent and current spatial/temporal management of groundfish has been designed to reduce fishing pressure on spawning aggregations.

- **Reasonably Foreseeable Future External Effects.** Several external factors have the potential to cumulatively affect the genetic diversity of the BSAI and GOA ecosystems. Atlantic salmon escapes from coastal net-pen farms in Washington State and British Columbia could establish Alaskan runs and viable populations (ADF&G 2002a, Fay 2002). Subsistence harvests of fish could concentrate effort on the same specific subpopulations from year to year, inadvertently but selectively depleting genetically distinct stocks. Similarly, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, belugas, harbor seals), may also deplete genetic diversity. The potential for introduced exotic invertebrates to establish viable populations in the BSAI and GOA will unavoidably continue with fishing vessel and commercial shipping traffic in the future. Such exotics may also include pathogens introduced by Pacific salmon that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and make it easier for introduced exotics to establish viable populations.

- **Cumulative Effects.** The implementation of FMP 1 is predicted to have an insignificant cumulative effect on genetic diversity. Several external factors, such as Atlantic salmon escapes, subsistence harvests of marine mammals that concentrate on the same subpopulations year after year, exotic species introduced through commercial shipping traffic, and climatic facilitation of viable exotic populations, have the potential to produce changes in the genetic diversity of the BSAI and GOA ecosystems. None of these, however, would affect the genetic diversity of species targeted or taken incidentally by the groundfish fisheries.

4.5.11 Summary of Alternative 1 Analysis

The direct, indirect, and cumulative ratings for all resource categories analyzed under this alternative are summarized in Tables 4.5-83 through 4.5-89.

Table No.	Resource Category	Components	Section 4.5 Reference
4.5-83	Target Groundfish Species	BSAI and GOA Walleye Pollock, BSAI and GOA Pacific Cod, BSAI and GOA Sablefish, BSAI and GOA Atka Mackerel, BSAI Yellowfin Sole, GOA Shallow Water Flatfish, BSAI Rock Sole, BSAI and GOA Flathead Sole, BSAI and GOA Arrowtooth Flounder, BSAI Greenland Turbot, GOA Deepwater Flatfish, BSAI Alaska Plaice, BSAI Other Flatfish, GOA Rex Sole, BSAI and GOA Pacific Ocean Perch, GOA Thornyhead Rockfish, BSAI and GOA Northern Rockfish, BSAI and GOA Shortraker/Rougheye Rockfish, BSAI Other Rockfish, GOA Slope Rockfish, GOA Pelagic Shelf Rockfish, GOA Demersal Shelf Rockfish	4.5.1
4.5-84	Prohibited, Other, Forage and Non-specified Species	Pacific Halibut, Pacific Salmon and Steelhead Trout, Pacific Herring, Crab Other Species Category Forage Fish Category Grenadier	4.5.2 4.5.3 4.5.4 4.5.5
4.5-85	Habitat	BSAI, GOA	4.5.6

Table No.	Resource Category	Components	Section 4.5 Reference
4.5-86	Seabirds	Black-footed Albatross, Laysan Albatross, Short-tailed Albatross, Northern Fulmar, Shearwaters, Storm-petrels, Cormorants, Spectacled Eider, Steller's Eider, Jaegers, Gulls, Kittiwakes, Terns, Murres, Guillemots, Murrelets, Auklets, Puffins	4.5.7
4.5-87	Marine Mammals	Steller Sea Lion, Northern Fur Seals, Pacific Walrus, Harbor Seals, Spotted Seal, Bearded Seal, Ringed Seal, Ribbon Seal, Northern Elephant, Sea Otter, Blue Whale, Fin Whale, Sei Whale, Minke Whale, Humpback Whale, Gray Whale, Northern Right Whale, Bowhead Whale, Sperm Whale, Beaked Whales (Baird's, Cuvier's and Stejneger's), Pacific White-Sided Dolphin, Killer Whale, Beluga Whale, Harbor Porpoise, Dall's Porpoise	4.5.8
4.5-88	Socioeconomics	Harvesting and Processing Sector (Catcher Vessels, Catcher Processors, Inshore Processors and Motherships) Regional Socioeconomic Profiles (Population, Processing Ownership and Activity, Catcher Vessel Ownership and Activity, Tax Revenue, Employment and Income) CDQ Allocations Subsistence (Subsistence Use of Groundfish, Subsistence Use of Steller sea lions, Salmon Subsistence Fisheries, Indirect Subsistence Factors: Income and Joint Production) Environmental Justice Market Channels and Benefits to U.S. Consumers (Product Quantity, Product Year-Round Availability, Product Quality, Product Diversity) Non-Market Goods (Benefits Derived from Marine Ecosystems and Associated Species)	4.5.9.1 4.5.9.2 4.5.9.3 4.5.9.4 4.5.9.5 4.5.9.6 4.5.9.7
4.5-89	Ecosystem	Forage Fish Availability, Spatial/Temporal Concentration of Fisheries, Introduction of Non-Native Species, Removal of Top Predators, Energy Redirection, Energy Removal, Species Diversity, Guild Diversity, Genetic Diversity	4.5.10

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4.6 Alternative 2 Analysis

The goal of Alternative 2 is to have a more aggressive harvesting policy while preventing overfishing. This alternative is described in detail in Section 2.6.3.

4.6.1 Target Groundfish Species Analysis

This section examines the potential direct, indirect, and cumulative effects that the implementation of Alternative 2 is expected to have on the target groundfish species. The potential effects of two policy "bookends" are analyzed, FMP 2.1 and FMP 2.2. These represent the policy boundaries of Alternative 2. As actually implemented, Alternative 2 could include policy measures anywhere within the range between the two bookends. The impact analyses start with the baseline (2002) status of the BSAI and GOA target groundfish stocks described in Section 3.5.1, including past trends that are likely to persist into the foreseeable future. Then, a computer-based analytic model is used to project how specific characteristics of the target groundfish stocks would respond directly and indirectly to management actions under each FMP. These projections from the model are the predicted direct and indirect effects (impacts) of the FMP on the target groundfish stocks. Section 4.1.5 describes the analytic model and explains how it is applied.

The model output for each target groundfish stock is defined in terms of collected data and calculated measures that are standards used by fisheries managers to regulate the number of fish removed from the sea so that the fisheries will be sustainable over the long-term. These data and measures include the fishing mortality rate (F), the overfishing level (OFL), total and spawning biomass levels (B), the minimum stock size threshold (MSST), maximum sustainable yield (MSY), mean age of the stock in years, and the sex ratio of the stock (number of males compared to number of females). As discussed in the following subsections, relevant data are not always available for all stocks. When data gaps prevent application of the model to a specific stock, the projected direct or indirect effect is evaluated as unknown (U).

Each target groundfish stock is modeled with respect to the following direct and indirect effects:

Direct Effects

Fishing Mortality: This is the rate at which the stock is depleted by direct mortality imposed by removing the fish from the sea.

Change in Biomass Level: This is the change over time in the biomass of the stock, as measured in metric tons (mt). Two measures are used: total biomass, which is the estimated biomass of the entire stock, and spawning biomass, which is the estimated biomass of all of the spawning females in the stock.

Spatial/Temporal Concentration of Catch: This is the degree to which the fishery will concentrate in a particular geographic area during a particular period of time each season. This pattern in space and time can affect fishing mortality and can also influence habitat suitability for spawning, rearing, and feeding.

Direct and/or Indirect Effects

Habitat Suitability: This is the degree to which habitat has the right characteristics to support the target stock at one or more life-history stages (spawning, rearing of juveniles, availability of food at all stages, availability

of refuge areas to allow escape from predators at all stages). Habitat suitability can be affected directly, for example by mechanical damage from bottom trawling, or influenced indirectly, for example by the gradual depletion of corals that provide hard substrate.

Prey Availability: This is the extent to which prey species are present in the environment and available as food to the target stock. Like habitat suitability, this measure can be affected directly, for example by the direct removal of prey species by the fishery, or indirectly, for example by a change in the structure of the food web.

To determine their probable significance, the projected direct and indirect effects in each of the impact categories listed above are evaluated against significance criteria. The criteria are designed to be relevant and meaningful in terms of the target groundfish stocks. Each significance criterion includes a threshold value above (or below) which the projected effect would be considered significant. Each criterion also includes a definition of what would constitute a beneficial (positive, +) or adverse (negative, -) effect. The possible evaluations are significant and beneficial (S+), insignificant (I), significant and adverse (S-), and unknown (U). Evaluations of conditionally significant beneficial or adverse (CS + or -) are not made for projected direct and indirect effects on target groundfish species, because the model can show only whether the significance threshold is or is not exceeded. The significance criteria used for the target groundfish stocks are presented in Appendix A, Table 4.1-1.

Each of the following subsections presents the model results and rationale for the expected direct and indirect effects of FMPs 2.1 and 2.2 on the target groundfish stocks. The significance ratings for these potential direct and indirect effects are presented in Appendix A, Table 4.6-1. Following the direct and indirect effects discussions on each stock, the expected cumulative effects on that stock are evaluated and discussed. The evaluation of potential cumulative effects builds on the direct and indirect effects evaluations as a starting point, and then brings in persistent past effects as well as reasonably foreseeable future natural events and human activities external to fisheries management. The cumulative effects assessment method uses the same impact categories and significance criteria discussed above for direct and indirect effects. This method is described further in Section 4.1.4.

4.6.1.1 Pollock

This section provides the direct, indirect and cumulative effects analysis for BSAI and GOA pollock for each of the bookends under Alternative 2. Numerous fishery management actions have been implemented that affect the pollock fisheries in the EBS and GOA. These actions are described in more detail in Sections 3.5.1.1 and 3.5.1.15 of this Programmatic SEIS. Pollock is managed as separate stocks in the BSAI and GOA, and falls under Tier 1 in both the BSAI and GOA groundfish FMPs.

Direct/Indirect Effects of FMP 2.1

FMP 2.1 includes the following features:

- The ABC is increased to be equivalent to the OFL level, and the F_{OFL} fishing rate is not lowered for stock sizes below $B_{40\%}$.

- The BSAI optimum yield range of 1.4 - 2.0 million mt is removed, and the optimum yield is set to the sum of the individual species OFL levels.

- PSC limits and bycatch limits are removed.

- Trawl closure areas and gear restrictions are removed.

- Fishing is allowed in current closed areas, such as Walrus Island closures, red king crab savings area, Bogoslof area, Pribilof Island closure, and nearshore Bristol Bay closure.

Total Biomass

Total biomass (ages 1 through 15+) of EBS pollock at the start of 2002 is estimated to be 12.97 million mt. Model projections of future total EBS pollock biomass are shown in Table H.4-1 of Appendix H. Under FMP 2.1, model projections indicate that EBS pollock biomass is expected to decrease to a value of about 9.6 million mt in 2005, then stabilize to about 10.0 million mt. The 2003-2007 average total biomass is 10.2 million mt. This reduction in biomass under FMP 2.1 is expected to have a significantly adverse impact on the EBS pollock stock.

In the Aleutian Islands region, the assessments are based trawl surveys that occur every other year. The most recent assessment indicates a biomass level of 175,000 mt. Given that under FMP 2.1 directed fishing for pollock in this region is allowed, the expectation is that the stock will remain stable or decrease in the future. A similar pattern is expected for the Bogoslof Island (however, catch data from this region were unavailable for inclusion in the projection analysis).

For GOA pollock, the age 2-10+ biomass is expected to increase under this FMP from a 2003 low of 800,000 mt to 1,070,000 mt by 2007 (Table H.4-23 of Appendix H). The average biomass over this period is expected to be 941,000 mt. This increase is anticipated primarily because recruitment is expected to improve from the recent series of relatively low levels. Thus, the effects of FMP 2.1 on the GOA pollock stock are considered to be insignificant.

Spawning Biomass

Female spawning biomass of EBS pollock in 2002 is estimated to be about 3.68 million mt. Model projections of future levels are shown in Table H.4-1 of Appendix H and Figure H.4-1 of Appendix H. Under FMP 2.1, projections indicate that EBS pollock spawning biomass will decrease to about 60 percent of the 2002 level by 2007. The projected average for 2003-2007 is 2.43 million mt.

In the Aleutian Islands region, spawning biomass is monitored by biannual trawl surveys. In the Bogoslof Island region, spawning stock is monitored by echo-integration trawl surveys. Since under FMP 2.1 these areas are expected to have relatively large increases in fishing (compared to 2002), we expect the spawning stock size to be stable or decrease in these regions.

The 2002 GOA female spawning biomass is estimated at about 136,000 mt and is anticipated to increase steadily to 171,000 mt by 2007 under FMP 2.1. This is below the estimated B_{msy} level of 210,000 mt with

an average over 2003-2007 of 148,300 mt. Model projections of future levels are shown in Table H.4-23 of Appendix H and Figure H.4-12 of Appendix H.

Fishing Mortality

The estimated fishing mortality for the EBS pollock stock in 2002 is 0.187. Model projections show this fishing mortality will increase by about 140 percent and equal the $F_{35\%}$ value of 0.448 for the period 2003-2007 (Table H.4-1 of Appendix H). Fishing mortality for the Bogoslof and Aleutian Islands region is expected to increase to the natural mortality rate of 0.3 under FMP 2.1 (Table H.4-2 of Appendix H).

For the GOA, fishing mortality in 2002 is estimated at 0.174 with projections increasing to the $F_{35\%}$ levels of 0.350 for all projection years (Table H.4-23 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 2.1 involves the resumption of fishing in a number of areas currently closed, and these areas are largely in the Aleutian Islands. It is unknown how changes in spatial/temporal concentrations will affect pollock stocks. Since pollock are relatively low-valued groundfish species, the viability of pollock fisheries may be sensitive to changes in pollock densities and concentrations. However, the concentration of the harvest is not expected to be of a magnitude to sufficiently alter the genetic structure or reproductive success of either the EBS or GOA populations.

Status Determination

Under FMP 2.1, the ABC is set equal to the OFL, removing the buffer between these two harvest regulations. Model projections of future catches of EBS and GOA pollock are at or below the OFL level from 2003 to 2008. For GOA pollock, the stock is expected to be above the MSST for the years 2003-2007. The EBS pollock stock appears to be above the MSST during the years 2003-2005, but for 2006 and 2007, the stock may be declared as below the MSST and require separate management measures for a rebuilding plan (since a 10-year projection from the 2006 and 2007 years result in spawning biomass estimates that are below the B_{msy} level in 2016 and 2017).

Age and Size Composition

Under FMP 2.1, the mean age of the EBS pollock stock at the end of 2007, as computed in model projections, is 2.32 years (Table H.4-1 of Appendix H). This compares with a mean age in the equilibrium unfished stock of 3.16 years. For GOA pollock the 2007 value is 2.77 years compared with an unfished estimate of 3.60 years (note that the GOA pollock assessment is modeled from age 2-10+ while the EBS pollock is modeled from age 1-15+) (Table H.4-23 of Appendix H).

Sex Ratio

In the models, the sex ratio of GOA and BSAI pollock is assumed to be 50:50. However, observer data and information from surveys are routinely collected and used to monitor the sex ratios of these stocks. Based on these data, it is unlikely that the sex ratio will be affected under FMP 2.1. However, since the catch levels are much higher than the 2002 levels, this assertion becomes more tenuous.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 2.1.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. An evaluation of potential trophic interactions is presented in Section 3.10. Since the catch is much higher than in 2002, it may cause significant qualitative changes in predator-prey interactions as a result of actions taken under FMP 2.1 (for the period 2003-2007). However, changes in prey availability are not expected to jeopardize the ability of either the EBS or GOA pollock stocks to sustain at or above the MSST. Therefore, FMP 2.1 would have an insignificant effect on EBS and GOA pollock through prey availability.

Summary of Effects of FMP 2.1 on Pollock

Although the ABC and OFL levels for pollock are equivalent under FMP 2.1, the F_{OFL} is not reduced for lower stock sizes, and the harvest of pollock under FMP 2.1 is increased relative to recent levels, the fishing rates on pollock drops below the B_{msy} reference point. This is substantially different than the pattern in recent years (and the baseline 2002 data). It could be argued that these levels are within accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. However, the direct and indirect effects of FMP 2.1 on EBS pollock biomass are considered significant (Table 4.6-1).

Cumulative Effects of FMP 2.1

External effects and the resultant cumulative effects associated with FMP 2.1 are shown in Tables 4.5-1 and 4.5-2.

EBS Pollock

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the EBS pollock stock is insignificant under FMP 2.1 (see Section 4.6.1.1).

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the EBS pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the BSAI pollock populations (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Removals of pollock occur in the Russian pollock fishery, and the catch is not accounted for in the annual harvest rates set for the US fishery. Therefore, the removals can be considered a potential adverse effect on fishing mortality. Catch and bycatch of pollock in the State of Alaska pollock fisheries are not considered to be contributors to

fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.1 is identified for mortality of EBS pollock, and is insignificant. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the EBS pollock stock is expected to be significantly adverse under FMP 2.1 (see Section 4.6.1.1).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.1), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to removals in the Russian and State of Alaska pollock fisheries. However, any future removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to pollock mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effects for change in biomass is identified under FMP 2.1. The effect is determined to be significantly adverse. Under this FMP, a large percentage reduction in biomass over the period 2003-2007 is predicted. The pollock stock is predicted to fall below MSST over the modeled period. The external factors are not expected to improve or mitigate the effect. Therefore the cumulative effect is judged to be significantly adverse.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal distribution of catch is considered to be insignificant under FMP 2.1 (see Section 4.6.1.1).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.1) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had a beneficial effect on pollock recruitment by reducing the adult pollock biomass, lingering

beneficial effects are identified for change in reproductive success. In addition, past commercial whaling and sealing also removed large predators of pollock adding to the potential for reproductive success of the stock. Lingering past effects are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** The Russian and State of Alaska pollock fisheries are identified as having potential adverse contributions to changes in genetic structure. However, removals in these fisheries could have a potential beneficial effects on pollock recruitment by reducing the adult pollock biomass. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** The cumulative effect on pollock reproductive success and genetic variability is considered insignificant under FMP 2.1. The concentration of harvest by the groundfish fisheries in combination with external effects are not expected to be of sufficient magnitude to adversely effect this stock.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that FMP 2.1 would have insignificant effects on pollock prey availability (see Section 4.6.1.1).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of pollock prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on pollock prey species are potentially adverse or beneficial; a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries are determined to have potential adverse contributions since bycatch and catch of forage species is likely to occur.

- **Cumulative Effects.** Cumulative effects are identified for prey availability, and the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the pollock stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, as described in Section 4.6.1.1 FMP 2.1 would have insignificant effects on pollock habitat suitability.

- **Persistent Past Effects.** Past effects identified for EBS pollock stocks include past foreign, JV, and domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.1). Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the EBS. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the Russian and State of Alaska fisheries since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the EBS pollock stock could be either beneficial or adverse since a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, its effect on the EBS pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is jeopardized.

GOA Pollock

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA pollock stock is insignificant under FMP 2.1 (see Section 4.6.1.1 Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, State of Alaska, and bait fisheries are not expected for the GOA pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the GOA pollock populations (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** Catch and bycatch of pollock in the State of Alaska pollock fisheries and State of Alaska shrimp fisheries are not considered to be contributors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.1, are identified for mortality of GOA pollock, but the effects are judged to be insignificant for the FMP. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA pollock stock is expected to be insignificant under FMP 2.1. As modeled under the FMP, the age 2-10+ biomass of GOA pollock is expected to increase (see Table H.4-23 of Appendix H). The increase is anticipated primarily because recruitment is expected to improve from recent low levels.

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.15), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to removals in the State of Alaska pollock and shrimp fisheries. However, any future removals are not expected to affect the ability of the stock to maintain MSST. Marine pollution is identified as having a potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to pollock mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** Cumulative effects for change in biomass are identified under the FMP 2.1; however, the combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized. Therefore, the effects of FMP 2.1 on GOA pollock through the change in biomass are considered insignificant.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As the density and quotas of pollock change during the modeled period, the concentration of the pollock fishery will change from the 2002 pattern; although, it is not possible to predict exactly how the pattern will change. However, the concentration of harvest by the groundfish fisheries is not expected to be of sufficient magnitude to adversely effect this stock. Therefore, FMP 2.1 is considered to have insignificant effects on GOA pollock through genetic structure and reproductive success.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.15) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** State of Alaska pollock fisheries and the State of Alaska shrimp fishery are identified as potential adverse contributors. However, these fisheries are unlikely to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** The cumulative effect on pollock reproductive success and genetic variability is considered insignificant under FMP 2.1. The concentration of harvest by the groundfish fisheries in combination with external effects are not expected to be of sufficient magnitude to adversely effect this stock. Therefore, the effects of FMP 2.1 on GOA pollock through the change in reproductive success and genetic variability are considered insignificant.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, as described under direct/indirect effects, the FMP would have insignificant effects on pollock prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign, state, and domestic fisheries catch and bycatch of pollock prey species, and the effects of EVOS on these species, are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for EBS pollock, climate changes and regime shifts could have potentially adverse or beneficial effects on pollock prey species. The other fisheries are determined to be potential adverse contributors. Since bycatch and catch of forage species used by pollock is unlikely to occur.

- **Cumulative Effects.** Cumulative effects are identified for prey availability under the FMP, and the combination of internal and external removals of prey is not expected to decrease prey availability such that the pollock stock is unable to sustain itself at or above MSST. Therefore, the cumulative effect of FMP 2.1 on GOA pollock through prey availability is considered insignificant.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, as described under direct/indirect effects, the FMP would have insignificant effects on pollock habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA pollock stocks include past foreign, JV, and State of Alaska, and domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.15). Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska pollock and shrimp fisheries since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA pollock stock would be either adverse or beneficial as described for EBS pollock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, the effects on the GOA pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is jeopardized.

Direct/Indirect Effects of FMP 2.2

FMP 2.2 is less aggressive than FMP 2.1, and is similar to FMP 1 in many respects with the following exceptions:

- Current bycatch and incidental catch restrictions are removed.

- The BSAI optimum yield range of 1.4 - 2.0 million mt is removed, and the optimum yield is set to the sum of the individual species ABC levels.

Total Biomass

Total biomass (ages 1 through 15+) of EBS pollock at the start of 2002 is estimated to be 12.97 million mt. Model projections of future total EBS pollock biomass are shown in Table H.4-1 of Appendix H Under FMP 2.2, model projections indicate that EBS pollock biomass is expected to decrease to a value of about 10.3 million mt in 2005, then increase to about 10.9 million mt by 2007. The 2003-2007 average total biomass is 10.8 million mt. Because the EBS pollock are above their respective MSST in the year 2002 and in all subsequent projection years, the effects of FMP 2.2 on EBS pollock through the change in biomass is insignificant.

In the Aleutian Islands region, the assessments are based trawl surveys that occur every other year. The most recent assessment indicates a biomass level of 175,000 mt. If under FMP 2.2, directed fishing for pollock in this region is allowed, the expectation is that the stock will remain stable or decrease in the future. A similar pattern is expected for the Bogoslof Island.

For GOA pollock, the age 2-10+ biomass is expected to increase under this FMP from a 2003 low of 800,000 mt to 1,240,000 mt by 2007 (Table H.4-23 of Appendix H). The average biomass over this period is expected to be 1,040,000 mt. This increase is anticipated primarily because recruitment is expected to improve from the recent series of relatively low levels. Thus, the effects of FMP 2.2 on GOA pollock through the change in biomass is considered insignificant.

Spawning Biomass

Female spawning biomass of EBS pollock in 2002 is estimated to be about 3.68 million mt. Model projections of future levels are shown in Table H.4-1 Appendix H. Under FMP 2.2, projections indicate that EBS pollock spawning biomass will decrease to about 67 percent of the 2002 level by 2007. The projected average for 2003-2007 is 2.73 million mt.

In the Aleutian Islands region, spawning biomass is monitored by biannual trawl surveys. In the Bogoslof Island region, spawning stock is monitored by echo-integration trawl surveys. Since under FMP 2.2 these areas may have developed fisheries, we expect the spawning stock size to remain stable or decrease in these regions.

The 2002 GOA female spawning biomass is estimated at about 136,000 mt and is anticipated to increase steadily to 240,000 mt by 2007 under FMP 2.2. This is above the estimated B_{msy} level of 210,000 mt although the average from 2003-2007 is 188,000 mt. Model projections of future levels are shown in Table H.4-23 Appendix H.

Fishing Mortality

The estimated fishing mortality for the EBS pollock stock in 2002 is 0.187. Model projections show this fishing mortality will increase by about 69 percent and average 0.315 for the period 2003-2007. These values are below the $F_{35\%}$ level of 0.448 and the $F_{40\%}$ level of 0.342, which are taken as proxies for F_{ABC} and F_{OFL}, respectively. This pattern in fishing mortality is due to the fact that the projected catch is expected to come closer to the actual ABC in future years. The proportion of SPR conserved under these mortality rates is 40 percent in 2003. The average implied SPR rate of fishing from 2003-2007 is 42 percent, well below the value estimated for 2002 (indicating a higher fishing mortality rate for this FMP) (Table H.4-1 of Appendix H). Thus, the effect of FMP 2.2 on EBS pollock through mortality is considered insignificant. Fishing mortality for the Bogoslof and Aleutian Islands region may increase to 75 percent of natural mortality under FMP 2.2 (Table H.4-2 of Appendix H).

For the GOA, fishing mortality in 2002 is estimated at 0.174 with projections suggesting a decrease to 0.126 in 2003 followed by increases to 0.172 by 2007. The values for $F_{35\%}$ and $F_{40\%}$ are 0.350 and 0.294, respectively. The SPR rate in 2002 is estimated at 55 percent and averages about 60 percent for the period 2003-2007. This fishing mortality rate pattern is due to the fact that under this FMP, the F_{ABC} is adjusted while the spawning stock is below $B_{40\%}$ (Table H.4-23 of Appendix H). Thus, the effect of FMP 2.2 on GOA pollock through mortality is considered insignificant.

Spatial/Temporal Concentration of Fishing Mortality

The harvest of EBS pollock occurs largely along the western edge of the EBS shelf during the summer and around the southern areas east of 170°W during the winter season (Jan 20-March). Under FMP 2.2, an average of 1.67 million mt of EBS pollock is projected to be harvested annually from 2003-2007 with spatial/temporal allocations as presented in Section 3.5.1.1. This concentration of harvest is not expected to be of sufficient magnitude to alter the genetic variability or reproductive success of the EBS pollock stock. The Bogoslof and Aleutian Island concentration of fishing mortality is anticipated to remain unchanged over this projection period.

In the GOA, pollock fishery in a broad variety of locales and regional quotas are allocated by season as presented in Section 3.5.1.15. Under FMP 2.2, an average of 75,600 mt of GOA pollock is projected to be harvested annually during 2003-2007 with the largest catch expected to be 111,000 mt in 2007. As the density and quotas of pollock change during this period, the concentration of the pollock fishery will likely change from the 2002 pattern. However, this concentration of harvest is not expected to be of sufficient magnitude to alter the genetic variability or reproductive success of the GOA pollock stock.

Status Determination

Under FMP 2.2, the ABC is set at a lower level than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of EBS pollock are below the ABC and OFL levels in all years. The EBS pollock are above their respective MSST in the year 2002 and in all subsequent projection years.

For FMP 2.2, GOA pollock spawning biomass is below the B_{msy} (taken as $B_{35\%}$) in 2002 and remains below this level until 2007. However, based on 10-year status determinations projections, the stock is above the MSST for all years 2003-2007.

Age and Size Composition

Under FMP 2.2, the mean age of the EBS pollock stock at the end of 2007, as computed in model projections, is 2.43 years. This compares with a mean age in an equilibrium unfished stock of 3.16 years (Table H.4-1 Appendix H). For GOA pollock the 2007 value is 3.07 years compared with an unfished estimate of 3.60 years (note that the GOA pollock assessment is modeled from age 2-10+ while the EBS pollock is modeled from age 1-15+) (Table H.4-23 of Appendix H).

Sex Ratio

In the models, the sex ratio of EBS and GOA pollock is assumed to be 50:50. However, observer data and information from surveys are routinely collected and used to monitor the sex ratios of these stocks. Based on these data, it is unlikely that the sex ratio will be affected under FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 2.2.

Predation-Mediated Impacts

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. An evaluation of potential trophic interactions is presented in Section 3.10. It seems unlikely that significant qualitative changes in predator-prey interactions would be a result of actions taken under FMP 2.2 (for the period 2003-2007).

Summary of Effects of FMP 2.2 – Pollock

Because the EBS and GOA pollock are fished at less than the ABC and are above the minimum stock size threshold, the direct and indirect effects under FMP 2.2 are considered insignificant. Fishing rates are lower than accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity (Table 4.6-1).

Cumulative Effects of FMP 2.2 – EBS Pollock

While the internal modeling results change, the external effects and cumulative effects for FMP 2.2 in the EBS are the same as those discussed for FMP 1 and presented in Table 4.5-1. These effects are summarized below.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the EBS pollock stock is insignificant under FMP 2.2 (see Section 4.6.1.1 Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the EBS pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the BSAI pollock populations (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** As described for the FMP 2.1 cumulative effects section, removals of pollock occur in the Russian pollock fishery are considered to be a potential adverse contributor, while removals in the Alaska pollock fisheries are not considered to contribute to pollock mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution, and climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.2 is identified for mortality of EBS pollock, but the effect is judged to be insignificant. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the EBS pollock stock is expected to be insignificant under FMP 2.2 (see Section 4.6.1.1 Direct/Indirect Effects).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.1), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects are the same as those described above for FMP 2.1 and include the Russian and State of Alaska pollock fisheries, and marine pollution.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified, and the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Section 4.6.1.1 Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects under FMP 2.2 are identical to those discussed for FMP 2.1 and include lingering beneficial effects on reproductive success.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, the Russian and State of Alaska pollock fisheries have the potential to cause adverse effects on genetic structure and potential beneficial effects on pollock recruitment by reducing the adult pollock biomass. Cannibalism-related declines in pollock recruitment have been observed at high pollock spawning biomasses (see Section 3.5.1.1). Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration and the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify (see Section 4.6.1.1). However, it is determined that the FMP would have insignificant effects on pollock prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of pollock prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.1).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on pollock prey species could have potential beneficial or potential adverse effects (see the cumulative effects discussion for FMP 2.1). On the other hand, marine pollution has been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries shown on Table 4.5-1 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effects are insignificant since the combination of internal and external removals of prey species is not expected to decrease prey availability such that the pollock stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.2, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify (see Section 4.6.1.1 Direct/Indirect Effects). However, it is determined that the FMP would have insignificant effects on pollock habitat suitability.

- **Persistent Past Effects.** Past effects identified for EBS pollock stocks include past foreign, JV, and domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.1) Intense bottom trawling for pollock in the past fisheries likely disrupted habitat in areas of the EBS. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1 adverse effects are possible from the Russian and State of Alaska fisheries, and marine pollution. Impacts on habitat from climate changes and regime shifts on the EBS pollock stock could be either beneficial or adverse.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability, and the effects on the EBS pollock stock are insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is jeopardized.

GOA Pollock

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA pollock stock is insignificant under FMP 2.2 (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, State of Alaska, and bait fisheries are not expected for the GOA pollock stock. While large removals of pollock did occur in the past, there does not appear to be a lingering effect on the GOA pollock populations (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, catch and bycatch of pollock in the State of Alaska pollock fisheries, and State of Alaska shrimp fisheries are not considered to be contributors to fishing mortality in the cumulative case. Marine pollution is identified as having a potential adverse contribution, and climate changes and regime shifts are not identified as being contributors to pollock mortality.

- **Cumulative Effects.** Cumulative effects are identified for mortality of GOA pollock, and the effects are judged to be insignificant for the FMP. Pollock are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA pollock stock is expected to be insignificant under FMP 2.2 (see Section 4.6.1.1).

- **Persistent Past Effects.** While past large removals of pollock and other past effects on biomass have been identified (see Section 3.5.1.15), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described in FMP 2.1, effects on biomass are indicated due to removals in the State of Alaska pollock fisheries. Marine pollution is identified as having a potential adverse contribution to change in biomass, and climate changes and regime shifts are not identified as being contributors to pollock mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** Cumulative effects for change in biomass are identified, and the combination of internal and external factors is not expected to sufficiently reduce the pollock biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized. Therefore, the cumulative effect of FMP 2.2 on GOA pollock through the change in biomass is considered insignificant.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As the density and quotas of pollock change during the modeled period, the concentration of the pollock fishery will change from the 2002 pattern; it is not possible to predict exactly how the pattern will change. However, for GOA pollock under FMP 2.2, the stock is expected to be above MSST for the years 2003-2007 (see Direct/Indirect Effects). Therefore, impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of pollock and other past effects (see Section 3.5.1.15) have not had a lingering effect

on the ability of the stock to sustain itself above MSST. However, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, the State of Alaska pollock fisheries and marine pollution are identified as potential adverse contributors.

- **Cumulative Effects.** Cumulative effects are possible for spatial/temporal concentration under FMP 2.2; however, the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized. Therefore, the cumulative effects of FMP 2.2 on GOA pollock through the change in genetic structure and reproductive success are insignificant.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify (see above). However, as described under direct/indirect effects, the FMP would have insignificant effects on pollock prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign, state, and domestic fisheries catch and bycatch of pollock prey species, and the effects of EVOS on these species, are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on pollock prey species (see Section 3.5.1.15).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, climate changes and regime shifts could have potential adverse or beneficial effects on pollock prey species. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor, and the other fisheries shown on Table 4.5-2 are determined to be potential adverse contributors.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the combination of internal and external removals of prey is not expected to decrease prey availability such that the pollock stock is unable to sustain itself at or above MSST. Therefore, the cumulative effect of FMP 2.2 on GOA pollock through the change prey availability is considered are insignificant.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.2, as with prey-mediated impacts, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify (see Direct/Indirect Effects). However, it is determined that the FMP would have insignificant effects on pollock habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA pollock stocks include past foreign, JV, and State of Alaska, and domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.15). Intense bottom trawling for pollock in the past fisheries likely disrupted

habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects**. Future external effects are possible from the State of Alaska pollock and shrimp fisheries since either of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA pollock stock would be either adverse or beneficial as described for EBS pollock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability, and the effect on the GOA pollock stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the pollock stock to sustain itself at or above MSST is jeopardized.

4.6.1.2 Pacific Cod

Pacific cod are managed under Tier 3a in the BSAI and GOA.

Direct/Indirect Effects of FMP 2.1

Total Biomass

Total (ages 1 through 12+) biomass of BSAI Pacific cod at the start of 2002 is estimated to be 1,933,000 mt. Model projections of future total BSAI biomasses are shown in Table H.4-3 Appendix H. Under FMP 2.1, model projections indicate that total BSAI biomass is expected to increase to a value of 2,061,000 mt in 2003, then decrease to a value of 1,868,000 mt in 2007, with a 2003-2007 average value of 1,938,000 mt.

Total (ages 1 through 12+) biomass of GOA Pacific cod at the start of 2002 is estimated to be 568,000 mt. Model projections of future total GOA biomasses are shown in Table H.4-24 of Appendix H. Under FMP 2.1, model projections indicate that total GOA biomass is expected to increase steadily to a value of 631,000 mt in 2007, with a 2003-2007 average value of 598,000 mt.

Spawning Biomass

Spawning biomass of female BSAI Pacific cod at the start of 2002 was estimated to be 404,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-3 of Appendix H and Figure H. 4-2 of Appendix H. Under FMP 2.1, model projections indicate that BSAI spawning biomass is expected to decrease steadily to a value of 346,000 mt in 2007, with a 2003-2007 average value of 373,000 mt. Projected spawning biomass dips below the B_{MSY} proxy value of 361,000 mt in 2006 and 2007.

Spawning biomass of female GOA Pacific cod at the start of 2002 was estimated to be 97,900 mt. Model projections of future GOA spawning biomasses are shown in Table H.4-24 of Appendix H and Figure H. 4-13 of Appendix H. Under FMP 2.1, model projections indicate that GOA spawning biomass is expected to decrease to a value of 69,700 mt in 2006, then increase to a value of 71,700 mt in 2007, with a 2003-2007

average value of 74,800 mt. Projected spawning biomass dips below the B_{MSY} proxy value of 79,000 mt in 2004, 2005, 2006, and 2007.

Fishing Mortality

The fishing mortality rate imposed on the BSAI Pacific cod stock in 2002 was estimated to be 0.228. Model projections of future BSAI fishing mortality rates are shown in Table H.4-3 of Appendix H. Under FMP 2.1, model projections indicate that BSAI fishing mortality will increase to a value of 0.409 in 2003, then remain there through 2007, giving a 2003-2007 average of 0.409. This value is equal to the F_{MSY} proxy value of 0.409, which is the rate associated with the OFL for any value of biomass under this FMP.

The fishing mortality rate imposed on the GOA Pacific cod stock in 2002 was estimated to be 0.255. Model projections of future GOA fishing mortality rates are shown in Table H.4-24 of Appendix H. Under FMP 2.1, model projections indicate that GOA fishing mortality is expected to increase to a value of 0.421 in 2004, then decrease to a value of 0.417 in 2007, with a 2003-2007 average of 0.419. These values are equal to or slightly below the F_{MSY} proxy value of 0.421, which is the rate associated with the OFL for any value of biomass under this FMP.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.1, it is likely that fishing for BSAI and GOA Pacific cod would tend, to some extent, to be concentrated in space and time so as to coincide with concentrations of spawning fish. Evaluating the effects of such concentrations of fishing mortality is difficult for two reasons: 1) Such concentrations of fishing mortality have already been in place for many years. Although the stocks currently appear to be healthy despite such concentrations, the absence of a "control" treatment makes it difficult to determine which population characteristics are attributable specifically to the existing spatial/temporal concentrations of fishing mortality. 2) Pacific cod undergo large migrations and a large degree of genetic mixing appears to exist. Compared to a sedentary species with readily identifiable genetic subunits, this means that the effects of spatial/temporal concentrations of fishing effort are probably diluted to some extent, but also that their evaluation involves a larger number of difficult-to-estimate parameters.

Status Determination

Model projections of future catches of BSAI and GOA Pacific cod are equal to or below their respective OFLs in all years under FMP 2.1 (Table H.4-3 of Appendix H). The BSAI Pacific cod stock is projected to be above MSST in 2003-2006 but below MSST in 2007. The GOA Pacific cod stock is projected to be above MSST in 2003 but below MSST in 2004. Information from the projection model is insufficient to determine the status of GOA Pacific cod with respect to MSST in 2005-2007 under this FMP (Table H.4-24 of Appendix H).

Age and Size Composition

Under FMP 2.1, the projected mean age of the BSAI Pacific cod stock in 2008 is 2.6 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.2 years.

Under FMP 2.1, the projected mean age of the GOA Pacific cod stock in 2008 is 2.7 years. This compares with a mean age in the equilibrium unfished GOA stock of 3.2 years.

Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Pacific cod in both the BSAI and GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 on Pacific cod would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under this FMP.

Summary of Effects of FMP 2.1 – Pacific Cod

Relationship to Comparative Baseline

The comparative baselines for BSAI and GOA Pacific cod are identical: Neither stock is overfished, the biomass of both stocks is below $B_{40\%}$ and has been decreasing for the last few years, and all catch and bycatch are accounted for in the management of both stocks. Under FMP 2.1, both stocks are projected to fall below MSST at least once during the period 2003-2007, the biomass of both stocks is projected to be below $B_{40\%}$ throughout the period 2003-2007, the biomass of both stocks is expected to show an overall decrease during the period 2003-2007 and beyond, and all catch and bycatch would continue to be accounted for in the management of both stocks.

Significance of Direct and Indirect Effects

The criteria used to rate the significance of impacts of FMP 2.1 on the BSAI and GOA stocks of Pacific cod are identical to those used for the other groundfish stocks. The rating of conditionally significant (either beneficial or adverse) is not applicable to any of the direct or indirect effects of FMP 2.1 on BSAI or GOA Pacific cod.

For the BSAI and GOA Pacific cod stocks, the impact of FMP 2.1 on fishing mortality is rated insignificant, because the projection model indicates that fishing mortality would be less than or equal to the OFL throughout the period 2003-2007. However, the impact of FMP 2.1 on the biomass of the BSAI and GOA

Pacific cod stocks is rated significantly adverse, because the biomass of the BSAI Pacific cod stock is projected to fall below the MSST in 2007 and the GOA Pacific cod stock is projected to be below the MSST in 2004 (information from the projection model is insufficient to determine the status of GOA Pacific cod with respect to the MSST in 2005-2007 under this FMP).

The existing spatial-temporal concentration of the catch does not appear to have led to changes in the genetic structure of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST. Furthermore, the impacts of spatial-temporal concentration on genetic structure under FMP 2.1 are expected to be not much greater than those of the existing concentration. However, because the BSAI and GOA Pacific cod stocks are projected to fall below their respective MSSTs at least once during the period 2003-2007 under FMP 2.1, the available evidence is insufficient to conclude whether changes in genetic structure due to spatial-temporal concentration of the catch under FMP 2.1 would materially impact either stock's ability to maintain itself at or above the MSST. Therefore, the magnitude of this effect is rated unknown for both stocks.

The existing spatial-temporal concentration of the catch does not appear to have led to changes in the reproductive success of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST. Furthermore, the impacts of spatial-temporal concentration on reproductive success under FMP 2.1 are expected to be not much greater than those of the existing concentration. However, because the BSAI and GOA Pacific cod stocks are projected to fall below their respective MSSTs at least once during the period 2003-2007 under FMP 2.1, the available evidence is insufficient to conclude whether changes in reproductive success due to spatial-temporal concentration of the catch under FMP 2.1 would materially impact either stock's ability to maintain itself at or above the MSST. Therefore, the magnitude of this effect is rated unknown for both stocks.

The existing level of groundfish harvest does not appear to have led to changes in prey availability for the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST. However, the level of groundfish harvest under FMP 2.1 is expected to be somewhat higher than the existing level and the BSAI and GOA Pacific cod stocks are projected to fall below their respective MSSTs at least once during the period 2003-2007 under FMP 2.1. Nevertheless, the fact that Pacific cod prey on many things besides groundfish makes it unlikely that changes in prey availability under FMP 2.1 would materially impact either stock's ability to maintain itself at or above the MSST. Therefore, the magnitude of this effect is rated insignificant for both stocks.

The existing level of habitat disturbance does not appear to have led to changes in spawning or rearing success for the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST. Furthermore, the level of habitat disturbance under FMP 2.1 is expected to be not much greater than the existing level. However, because the BSAI and GOA Pacific cod stocks are projected to fall below their respective MSSTs at least once during the period 2003-2007 under FMP 2.1, the available evidence is insufficient to conclude whether changes in habitat suitability under FMP 2.1 would materially impact either stock's ability to maintain itself at or above the MSST. Therefore, the magnitude of this effect is rated unknown for both stocks (Table 4.6-1).

Cumulative Effects of FMP 2.1

For further information regarding persistent past effects listed below in the text and in the tables, see Sections 3.5.1.2 and 3.5.1.16. External effects and the resultant cumulative effects associated with FMP 2.1 are shown in Tables 4.5-3 and 4.5-4.

BSAI Pacific Cod

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Pacific cod stock is insignificant under FMP 2.1 (see Section 4.6.1.2).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the BSAI Pacific cod stock. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery and subsistence/personal use fishery in the BSAI, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.1 is identified for mortality of BSAI Pacific cod, and is judged to be insignificant. Model projections indicate catch will be equal to, but not exceed the OFL for all years, and all catch and bycatch from external fisheries are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events are not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Pacific cod stock is expected to be significantly adverse under FMP 2.1 (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the BSAI Pacific cod stock. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/personal use fishery in the BSAI. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified under FMP 2.1. The effect is judged to be significantly adverse. Due to the internal effects of the FMP, biomass of BSAI stock is projected to fall below the MSST in 2007. The additional mortality from external human controlled events will likely cause additional reduction in biomass.

<u>Spatial/Temporal Concentration of Catch</u>

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1, the effects of the spatial/temporal distribution of catch on the genetic structure and reproductive success of the population are unknown (see Section 4.6.1.2 Direct/Indirect Effects).

- **Persistent Past Effects.** Paste effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.2) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline and State of Alaska crab fisheries and subsistence use in the BSAI have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the significance of the effect is unknown. Evidence is insufficient to conclude whether the combined effects of the internal and external actions/events would impact the stock's ability to maintain itself at or above MSST.

<u>Change in Prey Availability</u>

- **Direct/Indirect Effects.** Any predation-mediated impacts of the FMP would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is

determined that FMP 2.1 would have insignificant effects on Pacific cod prey availability (see Section 4.6.1.2).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Pacific cod prey species could be either beneficial or adverse since a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability and the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific cod stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 levels of habitat disturbance may lead to changes in spawning or rearing success in the BSAI Pacific cod population. However, the evidence is insufficient to conclude that any changes that did occur would impact the stock's ability to sustain MSST. Therefore, the effect is rated as unknown (see direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects identified for BSAI Pacific cod stock include past foreign, JV, domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Section 3.5.1.2). Past fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the BSAI Pacific cod stock are unknown, although a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, its significance on the BSAI Pacific cod stock is unknown.

GOA Pacific Cod

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific cod stock is insignificant under FMP 2.1 (see Section 4.6.1.2).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries, and State of Alaska groundfish fisheries are identified for the GOA Pacific cod stock. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery, subsistence/personal use fishery, and in the State of Alaska groundfish fisheries in the GOA, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels for pollock and do not add additional fishing mortality. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.1 is identified for mortality of GOA Pacific cod, and the effect is judged to be insignificant. Model projections indicate catch will be equal to, but not exceed the OFL for all years, and all catch and bycatch from external fisheries are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific cod stock is expected to be significantly adverse under FMP 2.1 (see Section 4.6.1.2).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the GOA Pacific cod stock. Additionally, the State of Alaska groundfish fishery contributed to past removals in the GOA. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals

in the subsistence/personal use fishery and the State of Alaska groundfish fisheries in the GOA. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for the change in biomass is identified under FMP 2.1. The effect is judged to be significantly adverse. Due to the internal effects of the FMP, biomass of GOA stock is projected to fall below the MSST in 2004. The additional mortality from external human controlled events could cause additional reduction in biomass.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1, the effects of the spatial/temporal distribution of catch on the genetic structure and reproductive success of the population are unknown (see direct/indirect discussion).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.16) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline and State of Alaska crab fisheries, State of Alaska groundfish fisheries, and subsistence use in the GOA have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the significance of the effect is unknown. Evidence is insufficient to conclude whether the combined effects of the internal and external actions/events would impact the stock's ability to maintain itself at or above MSST.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of the FMP would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that FMP 2.1 would have insignificant effects on Pacific cod prey availability (see Section 4.6.1.2).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described in the discussion of the Bering Sea stock, climate changes and regime shifts on Pacific cod prey species in the GOA could be either beneficial or adverse depending on water temperature. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific cod stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 levels of habitat disturbance may lead to changes in spawning or rearing success in the GOA Pacific cod population. However, the evidence is insufficient to conclude that any changes that did occur would impact the stock's ability to sustain MSST. Therefore, the effect is rated as unknown (see Section 4.6.1.2).

- **Persistent Past Effects.** Past effects identified for GOA Pacific cod stock include past foreign, JV, domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, State of Alaska groundfish fisheries, and climate changes and regime shifts (see Section 3.5.1.16). Past fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. As described for the Bering Sea, impacts on habitat from climate changes and regime shifts on the GOA Pacific cod stock could be either beneficial or adverse. Marine pollution has been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, its significance on the GOA Pacific cod stock is unknown since the effect of the FMP is unknown.

Direct/Indirect Effects of FMP 2.2 – BSAI Pacific Cod

All direct and indirect effects of FMP 2.2 on BSAI Pacific cod are expected to be insignificant, because the analytic model results indicate that none of the threshold values for the significance criteria in Appendix A, Table 4.1-1 would be reached.

Total Biomass

Total (ages 1 through 12+) biomass of BSAI Pacific cod at the start of 2002 is estimated to be 1,933,000 mt. Under FMP 2.2, model projections indicate that total BSAI biomass is expected to increase to a value of 2,078,000 mt in 2004, then decrease to a value of 2,057,000 mt in 2006, then increase to a value of 2,072,000 mt in 2007, with a 2003-2007 average value of 2,065,000 mt.

Total (ages 1 through 12+) biomass of GOA Pacific cod at the start of 2002 is estimated to be 568,000 mt. Under FMP 2.2, model projections indicate that total GOA biomass is expected to increase steadily to a value of 675,000 mt in 2007, with a 2003-2007 average value of 622,000 mt.

Spawning Biomass

Spawning biomass of female BSAI Pacific cod at the start of 2002 was estimated to be 404,500 mt. Under FMP 2.2, model projections indicate that BSAI spawning biomass is expected to decrease to a value of 403,000 mt in 2003, then increase to a value of 435,000 mt in 2005, then decrease to a value of 425,000 mt in 2007, with a 2003-2007 average value of 422,000 mt. Projected spawning biomass never dips below the B_{MSY} proxy value of 361,000 mt for the years 2003-2007.

Spawning biomass of female GOA Pacific cod at the start of 2002 was estimated to be 97,900 mt. Under FMP 2.2, model projections indicate that GOA spawning biomass is expected to decrease to a value of 79,100 mt in 2005, then increase to a value of 85,700 mt in 2007, with a 2003-2007 average value of 83,100 mt. Projected spawning biomass never dips below the B_{MSY} proxy value of 79,000 mt for the years 2003-2007.

Fishing Mortality

The fishing mortality rate imposed on the BSAI Pacific cod stock in 2002 was estimated to be 0.228. Under FMP 2.2, model projections indicate that BSAI fishing mortality will increase to a value of 0.297 in 2004, then decrease to a value of 0.287 in 2007, with a 2003-2007 average of 0.293. These values are well below the F_{MSY} proxy value of 0.409, which is the rate associated with the OFL for stocks above $B_{40\%}$.

The fishing mortality rate imposed on the GOA Pacific cod stock in 2002 was estimated to be 0.255. Under FMP 2.2, model projections indicate that GOA fishing mortality is expected to increase to a value of 0.324 in 2003, then decrease to a value of 0.289 in 2005, then increase to a value of 0.312 in 2007, with a 2003-2007 average of 0.304. These values are well below the F_{MSY} proxy value of 0.421, which is the rate associated with the OFL for stocks above $B_{40\%}$.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.2, it is likely that fishing for BSAI and GOA Pacific cod would tend, to some extent, to be concentrated in space and time so as to coincide with concentrations of spawning fish. Evaluating the effects of such concentrations of fishing mortality is difficult for two reasons: 1) Such concentrations of fishing mortality have already been in place for many years. Although the stocks currently appear to be healthy despite such concentrations, the absence of a "control" treatment makes it difficult to determine which population characteristics are attributable specifically to the existing spatial/temporal concentrations of fishing mortality. 2) Pacific cod undergo large migrations and a large degree of genetic mixing appears to exist. Compared to a sedentary species with readily identifiable genetic subunits, this means that the effects of spatial/temporal concentrations of fishing effort are probably diluted to some extent, but also that their evaluation involves a larger number of difficult-to-estimate parameters.

Status Determination

Model projections of future catches of BSAI and GOA Pacific cod are below their respective OFLs in all years under FMP 2.2. The BSAI and GOA Pacific cod stocks are projected to be above $B_{35\%}$ and therefore above their respective MSSTs in every year throughout the period 2003-2007.

Age and Size Composition

Under FMP 2.2, the projected mean age of the BSAI Pacific cod stock in 2008 is 2.7 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.2 years.

Under FMP 2.2, the projected mean age of the GOA Pacific cod stock in 2008 is 2.8 years. This compares with a mean age in the equilibrium unfished GOA stock of 3.2 years.

Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Pacific cod in both the BSAI and GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.2 on Pacific cod would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is

insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under this FMP.

Summary of Effects of FMP 2.2 – Pacific Cod

Relationship to Comparative Baseline

The comparative baselines for BSAI and GOA Pacific cod are identical: Neither stock is overfished, the biomass of both stocks is below $B_{40\%}$ and has been decreasing for the last few years, and all catch and bycatch are accounted for in the management of both stocks. Under FMP 2.2, both stocks are projected to remain above MSST throughout the period 2003-2007. The biomass of the BSAI stock is projected to be below $B_{40\%}$ in 2003 but above $B_{40\%}$ in 2004-2007, while the biomass of the GOA stock is projected to be below $B_{40\%}$ throughout the period 2003-2007. The biomass of the BSAI stock is expected to show an overall increase during the period 2003-2007 and beyond, while the biomass of the GOA stock is expected to show an overall decrease during the period 2003-2007 and beyond. All catch and bycatch would continue to be accounted for in the management of both stocks.

Significance of Direct and Indirect Effects

The criteria used to rate the significance of impacts of FMP 2.2 on the BSAI and GOA stocks of Pacific cod are identical to those used for the other groundfish stocks. The rating of conditionally significant (either beneficial or adverse) is not applicable to any of the direct or indirect effects of FMP 2.2 on BSAI or GOA Pacific cod. Table 4.5-7 summarizes the effects of FMP 2.2 on Pacific cod stocks in the BSAI and GOA, respectively.

For the BSAI and GOA Pacific cod stocks, the impact of FMP 2.2 on fishing mortality and biomass is rated insignificant, because the projection model indicates that fishing mortality would be less than the OFL and biomass would be above the MSST throughout the period 2003-2007.

Because the existing spatial-temporal concentration of the catch does not appear to have led to changes in the genetic structure of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the impacts of spatial-temporal concentration on genetic structure under FMP 2.2 are expected to be not much greater than those of the existing concentration, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing spatial-temporal concentration of the catch does not appear to have led to changes in the reproductive success of the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the impacts of spatial-temporal concentration on reproductive success under FMP 2.2 are expected to be not much greater than those of the existing concentration, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing level of groundfish harvest does not appear to have led to changes in prey availability for the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the level of groundfish harvest under FMP 2.2 is expected to be not much greater than the existing level, the magnitude of this effect is rated insignificant for both stocks.

Likewise, because the existing level of habitat disturbance does not appear to have led to changes in spawning or rearing success in the BSAI or GOA Pacific cod populations that materially impact either stock's ability to maintain itself at or above the MSST and because the level of habitat disturbance under FMP 2.2 is expected to be not much greater than the existing level, the magnitude of this effect is rated insignificant for both stocks (Table 4.6-1).

Cumulative Effects of FMP 2.2 – BSAI Pacific Cod

For further information regarding past effects see Section 3.5.1.2. BSAI internal, external, and cumulative effects are depicted on Table 4.5-3.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Pacific cod stock is insignificant under FMP 2.2 (see direct/indirect effects discussion presented above).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the BSAI Pacific cod stock. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery and subsistence/personal use fishery in the BSAI, but they are not expected to be contributing factors to fishing mortality in the cumulative case. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.2 is identified for mortality of BSAI Pacific cod, and the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Pacific cod stock is expected to be insignificant under FMP 2.2 (see Section 4.6.1.2).

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.2), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1 effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/personal use fishery in the BSAI. Marine pollution is identified as

having a reasonably foreseeable potential adverse contribution to change in biomass, and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect on the change in biomass is identified, and the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the Pacific cod biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.2, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see direct/indirect effects discussion).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.2) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, the IPHC longline and State of Alaska crab fisheries, subsistence use in the BSAI, and marine pollution could contribute adversely to genetic changes and reduced recruitment.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration, and the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that FMP 2.2 would have insignificant effects on Pacific cod prey availability (see direct/indirect effects discussion).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.2).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, effects of climate changes and regime shifts on Pacific cod prey species could be either beneficial or adverse depending on water temperature. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor, and the other fisheries shown on Table 4.5-3 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific cod stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.2, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Because the level of habitat disturbance under the FMP is expected to be no greater than the existing level, the effect is rated as insignificant (see Section 4.6.1.2).

- **Persistent Past Effects.** Past effects identified for BSAI Pacific cod stock include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Section 3.5.1.2). Past fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery. Impacts on habitat from climate changes and regime shifts on the BSAI Pacific cod stock could be either beneficial or adverse and marine pollution could have an adverse effect on habitat.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability, and the combination of internal and external impacts on habitat is not expected to jeopardize the Pacific cod stock such that it is unable to sustain itself at or above MSST. Therefore, the effect of FMP 2.2 on BSAI Pacific cod through habitat suitability is considered insignificant.

GOA Pacific Cod

External effects and the resultant cumulative effects associated with FMP 2.2 are shown in Table 4.5-4.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific cod stock is insignificant under FMP 2.2 (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska bait fisheries are identified for the GOA Pacific cod stock. Additionally, the State of Alaska groundfish fishery

contributed to past removals in the GOA. Large removals of Pacific cod did occur in the past and could have a lingering effect on the present-day stock, the biomass of which is below $B_{40\%}$ (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1 in the GOA, bycatch and removals of Pacific cod are predicted to continue in the IPHC longline fishery, State of Alaska crab fishery, subsistence/personal use fishery, and in the State of Alaska groundfish fisheries in the GOA, but are not expected to be contributing factors to fishing mortality in the cumulative case. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution, and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.2 is identified for mortality of GOA Pacific cod, and the effect is judged to be insignificant. Pacific cod are fished at less than the OFL and all catch and bycatch are accounted for in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific cod stock is expected to be insignificant under FMP 2.2 (see Direct/Indirect Effects).

- **Persistent Past Effects.** While past large removals of Pacific cod and other past effects on biomass have been identified (see Section 3.5.1.16), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, effects on biomass are indicated due to bycatch in the IPHC longline and State of Alaska crab fisheries, and bycatch and removals in the subsistence/personal use fishery, and in the State of Alaska groundfish fisheries. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution, and climate changes and regime shifts are not identified as being contributors to Pacific cod mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect on the change in biomass is identified and the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the Pacific cod biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized. Therefore, the cumulative effect of FMP 2.2 on GOA pollock through the change in biomass is considered to be insignificant.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.2, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure since the past large removals of Pacific cod and other past effects (see Section 3.5.1.16) have not had a lingering effect on the ability of the stock to sustain itself above MSST. However, since past fisheries could have had an adverse effect on Pacific cod recruitment particularly in the GOA where the State of Alaska groundfish fishery is very localized, lingering effects are identified for change in reproductive success. Lingering past effects (either beneficial or adverse depending on the regime) are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, the IPHC longline and State of Alaska crab fisheries, subsistence use, and State of Alaska groundfish fisheries, and marine pollution all have the potential to cause adverse effects.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that FMP 2.2 would have insignificant effects on Pacific cod prey availability (see Direct/Indirect Effects).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Pacific cod prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific cod prey species (see Section 3.5.1.16).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1 in the GOA, the effects of climate changes and regime shifts on Pacific cod prey species could be either beneficial or adverse. Marine pollution has been identified as a reasonably foreseeable future external contributing factor, and the other fisheries shown on Table 4.5-4 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability and the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific cod stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.2, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, the effect is rated as insignificant (see Section 4.6.1.2).

- **Persistent Past Effects.** Past effects identified for GOA Pacific cod include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Section 3.5.1.16). Additionally, the State of Alaska groundfish fishery contributed to habitat impacts in the GOA. Past fishing for Pacific cod in the past fisheries likely disrupted habitat in areas of the GOA. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, effects are possible from the State of Alaska fisheries, subsistence, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the GOA Pacific cod stock could be either beneficial or adverse and marine pollution has been identified as a potential adverse contributing factor.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is considered insignificant. The combination of internal and external impacts on habitat is not expected to jeopardize the Pacific cod stock such that it is unable to sustain itself at or above MSST.

4.6.1.3 Sablefish

Sablefish are managed as one stock in the BSAI and GOA under Tier 3b; therefore, BSAI and GOA areas are discussed together in this section.

Direct/Indirect Effects of FMP 2.1

Direct/indirect effects are summarized in Table 4.6-1.

Catch/ABC

FMP 2.1 is projected to significantly increase average sablefish yield compared to the baseline. Higher yields are projected because a higher fishing rate ($F_{35\%}$) is used for F_{ABC}.

Total Biomass

FMP 2.1 is projected to have a significant impact on total biomass (age 2-31+) compared to the baseline. Fishing mortality is higher for this alternative (Tables H.4-11and H.4-30 of Appendix H). Total biomass is unchanged for this FMP rather than increasing as projected for alternatives that replicate baseline conditions.

Spawning Biomass

FMP 2.1 is projected to have a significantly adverse impact on spawning biomass compared to the baseline. Spawning biomass is projected to decrease by 2007, approaching some benchmarks that imply some risk to the reproductive success of the stock. Projected 2007 spawning biomass is 35 percent of the unfished value for this alternative, approaching the historic low spawning biomass (30 percent, 1975) and the lowest spawning biomass (34 percent, 1977) that produced above average year-classes (Sigler *et al.* 2002) (Tables H.4-11 and H.4-30 of Appendix H) and Figures H.4-9 and H.4-14 of Appendix H.

Fishing Mortality

Under FMP 2.1, the fishing mortalities imposed on the sablefish stock in the BSAI are well below the F_{MSY} proxy value of 0.14 which is the rate associated with the OFL. Fishing mortality is comparatively low because catch usually is less than ABC in the BSAI (Table H.4-11 of Appendix H). In contrast, the fishing mortalities imposed on the sablefish stock in the GOA are similar to the F_{MSY} proxy value of 0.14 which is the rate associated with the OFL (Table H.4-30 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

Sablefish fishing is concentrated along the upper continental slope and deepwater gullies. FMP 2.1 is projected to have an insignificant impact on the spatial/temporal concentration of fishing mortality compared to the baseline. Although numerous current closed/restricted areas are repealed by FMP 2.1, these repeals little affect areas where adult sablefish are caught.

Status Determination

Under FMP 2.1, sablefish is not overfished but is projected to be approaching an overfished condition. Sablefish spawning biomass is projected to fall below B_{MSY} ($B_{35\%}$ for Tier 3 stocks) and remain there for at least a decade.

Age and Size Composition

FMP 2.1 is projected to have an insignificant impact on mean age compared to the baseline. The mean age decreases somewhat due to increased fishing mortality, but not enough to be classified as significant. The mean ages actually observed in 2008 (as opposed to projections of mean ages) will be driven largely by incoming recruitment strengths during the intervening years.

BSAI mean age likely is overestimated. The model assumes that the lower exploitation rate for the BSAI compared to the GOA will translate into greater mean age for the BSAI. However sablefish migration is substantial enough to erase the effects of differential exploitation rates between the GOA and BSAI. The mean age for the GOA best represents the mean age for the BSAI/GOA because sablefish abundance is much greater for the GOA.

Sex Ratio

The sex ratio of the adult population is 40 males: 60 females, based on sex ratio data collected during sablefish longline surveys. This FMP probably would have no significant effect on the sex ratio compared to the baseline.

Habitat Suitability

FMP 2.1 would increase exploitation rates and so would increase any effects that additional fishing may have to decrease habitat suitability.

Predator-Prey Relationships

FMP 2.1 is projected to have a significant impact on total biomass (age 2-31+) compared to the baseline. Although total biomass doesn't change, fewer sablefish are projected for this FMP compared to alternatives that replicate baseline conditions. Thus this FMP is projected to have a significant effect on the amount of sablefish biomass that would be available to the ecosystem and the amount of predation that would be due to sablefish.

Cumulative Effects of FMP 2.1

External effects and the resultant cumulative effects associated with FMP 2.1 are depicted on Table 4.5-5. For further information regarding persistent past effects listed below in the text and in table, see the past/present effects analysis in Sections 3.5.1.3 and 3.5.1.17.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the sablefish stock is insignificant under FMP 2.1 (see Section 4.6.1.3).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska groundfish fisheries are identified for Sablefish. Large removals of Sablefish occurred, particularly in the JV and domestic fisheries. Catches that were under reported during the late 1980s may have contributed to abundance declines in the 1990s (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** While bycatch and removals of Sablefish are predicted to continue in the IPHC longline fishery, and State of Alaska groundfish fishery, these are not expected to be contributing factors to fishing mortality in the cumulative case. Removals in these fisheries are accounted for when setting annual harvest levels and do not add additional fishing mortality. Due the highly migratory nature, Canadian fisheries, fishing within Canadian waters could be harvesting sablefish considered to be part of the GOA population. These removals are not accounted for in the TAC setting process and can be considered as having a potential adverse contribution to the cumulative case. Likewise, marine pollution is identified as having a reasonably foreseeable potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to direct Sablefish mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.1 is identified for mortality of sablefish, and is judged to be insignificant. Sablefish are fished at less than the OFL and all catch and bycatch are accounted for (with the exception of any fish taken in Canadian waters) in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the Sablefish stock is expected to be significantly adverse under FMP 2.1 (see Direct/Indirect Effects).

- **Persistent Past Effects.** While past large removals of Sablefish and other past effects on biomass have been identified (see Sections 3.5.1.3 and 3.5.1.17), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Future external effects on biomass are indicated due to catch and bycatch in the IPHC longline and State of Alaska groundfish fisheries, and in the Canadian fisheries. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Sablefish mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified. The effect is judged to be significantly adverse since the combination of internal and external factors is expected to sufficiently reduce the Sablefish biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure or reproductive success. While spatial/temporal concentration of catch occurred in the State of Alaska directed sablefish fisheries, there are no lingering effects due to the migratory nature of the fish (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline and State of Alaska groundfish fisheries, and Canadian fisheries all have the potential to cause adverse effects. However, the removals are not expected to be sufficiently concentrated to alter the genetic structure of the population or affect recruitment. Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of harvest and is considered to be insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that the FMP would have insignificant effects on sablefish prey availability.

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Sablefish prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Sablefish prey species (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Sablefish prey species could be either beneficial or adverse since a strong Aleutian Low and high water temperatures tend to favor recruitment and cause a change in the reproductive success of the stock. Likewise, a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment (see Sections 3.5.1.3 and 3.5.1.17). Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The other fisheries are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the Sablefish stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that the FMP would have insignificant effects on sablefish habitat suitability (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects identified for Sablefish include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Sections 3.5.1.3 and 3.5.1.17). Past fishing for Sablefish in the past fisheries likely disrupted habitat in areas of the GOA and possibly the BSAI. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Future external effects are possible from the State of Alaska fisheries, and the IPHC fishery since any of these may impact bottom habitat through use of fishing gear. As described for prey availability impacts on habitat from climate changes and regime shifts on the Sablefish stock could be either beneficial or adverse depending on water temperature. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability and are considered insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the sablefish stock to sustain itself at or above MSST is jeopardized.

Direct/Indirect Effects of FMP 2.2

Direct/indirect effects are summarized in Table 4.6-1.

Catch/ABC

FMP 2.2 is projected to significantly increase average sablefish catch, but not ABC, compared to the baseline. Yields likely increase because fisheries where sablefish are caught as bycatch can catch the full ABC. For example, sablefish primarily are caught in a directed fishery, but also as bycatch in fisheries such as Greenland turbot in the Bering Sea. Setting the OY to the sum of the ABCs likely increases the amount of sablefish caught as bycatch.

Fishing Mortality

Under FMP 2.2, the fishing mortalities imposed on the sablefish stock are well below the F_{MSY} proxy value of 0.14 which is the rate associated with the OFL (Tables H.4-11and H.4-30 of Appendix H).

Total Biomass

FMP 2.2 is projected to have an insignificant impact on total biomass (age 2-31+) compared to the baseline. Fishing mortality is higher for FMP 2.2, but catches remain relatively small compared to total biomass, so that the increased catches have an insignificant impact on total biomass (Tables H.4-11 and H.4-30 of Appendix H).

Spawning Biomass

FMP 2.2 is projected to have an insignificant impact on spawning biomass compared to the baseline. Fishing mortality is higher for FMP 2.2, but catches remain relatively small compared to spawning biomass, so that the increased catches have an insignificant impact on spawning biomass (Tables H.4-11 and H.4-30 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

Sablefish fishing is concentrated along the upper continental slope and deepwater gullies. FMP 2.2 is projected to have an insignificant impact on the spatial/temporal concentration of fishing mortality compared to the baseline. FMP 2.2 closed areas are the same as baseline.

Status Determination

Under FMP 2.2, sablefish is not overfished nor approaching an overfished condition.

Age and Size Composition

FMP 2.2 is projected to have an insignificant impact on mean age compared to the baseline. The mean ages actually observed in 2008 (as opposed to projections of mean ages) will be driven largely by incoming recruitment strengths during the intervening years.

BSAI mean age likely is overestimated. The model assumes that the lower exploitation rate for the BSAI compared to the GOA will translate into greater mean age for the BSAI. However sablefish migration is substantial enough to erase the effects of differential exploitation rates between the GOA and BSAI. The mean age for the GOA best represents the mean age for the BSAI/GOA because sablefish abundance is much greater for the GOA.

Sex Ratio

The sex ratio of the adult population is 40 males: 60 females, based on sex ratio data collected during sablefish longline surveys. This FMP probably would have no significant effect on the sex ratio compared to the baseline.

Habitat Suitability

FMP 2.2 would increase exploitation rates and so would increase any effects that additional fishing may have to decrease habitat suitability.

Predator-prey Relationships

FMP 2.2 is projected to have an insignificant impact on total biomass (age 2-31+) compared to the baseline, so this FMP should have an insignificant effect on the amount of sablefish biomass available to the ecosystem and the amount of predation due to sablefish.

Cumulative Effects of FMP 2.2

External effects and the resultant cumulative effects associated with FMP 2.2 are depicted on Table 4.5-5. For further information regarding persistent past effects listed below in the text and in table, see the past/present effects analysis in Sections 3.5.1.3 and 3.5.1.17.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the sablefish stock is insignificant under FMP 2.2 (see direct/indirect effects discussion above).

- **Persistent Past Effects.** Past effects of the foreign, JV, domestic, and State of Alaska groundfish fisheries are identified for Sablefish. Large removals of Sablefish occurred, particularly in the JV and domestic fisheries. Catches that were under reported during the late 1980s may have contributed to abundance declines in the 1990s (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, bycatch and removals of Sablefish are predicted to continue in the IPHC longline fishery, State of Alaska

groundfish fishery, but these are not expected to be contributing factors to fishing mortality in the cumulative case. Due the highly migratory nature, Canadian fisheries, fishing within Canadian waters could be harvesting sablefish considered to be part of the GOA population. These removals are not accounted for in the TAC setting process and can be considered as having a potential adverse contribution to the cumulative case. Likewise, marine pollution is identified as having a reasonably foreseeable potential adverse contribution, but climate changes and regime shifts are not identified as being contributors to direct Sablefish mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.2 is identified for mortality of sablefish and is judged to be insignificant. Sablefish are fished at less than the OFL and all catch and bycatch are accounted for (with the exception of any fish taken in Canadian waters) in the management of the stock. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the sablefish stock is expected to be insignificant under FMP 2.2 (see Section 4.6.1.3).

- **Persistent Past Effects.** While past large removals of sablefish and other past effects on biomass have been identified (see Sections 3.5.1.3 and 3.5.1.17), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, effects on biomass are indicated due to catch and bycatch in the IPHC longline and State of Alaska groundfish fisheries, and in the Canadian fisheries. Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass, but climate changes and regime shifts are not identified as being contributors to Sablefish mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified and is considered insignificant since the combination of internal and external factors is not expected to sufficiently reduce the Sablefish biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.2, the spatial/temporal distribution of catch should have an insignificant effect on the genetic structure and reproductive success of the population (see direct/indirect effects discussion for this FMP).

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure or reproductive success. While spatial/temporal concentration of catch occurred in the State of Alaska directed sablefish fisheries, there are no lingering effects due to the migratory nature of the fish (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, the IPHC longline and State of Alaska groundfish fisheries, Canadian fisheries and marine pollution, all have the potential to cause adverse effects.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration, and is considered insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that the FMP would have insignificant effects on sablefish prey availability (see Direct/Indirect Effects).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic and State of Alaska fisheries catch and bycatch of Sablefish prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on sablefish prey species (see Sections 3.5.1.3 and 3.5.1.17).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, effects of climate changes and regime shifts on Sablefish prey species could be beneficial or adverse. Marine pollution has been identified as a reasonably foreseeable future external contributing factor, and the other fisheries shown on Table 4.5-5 are determined to be potential adverse contributors since catch and bycatch of prey species are likely to continue.

- **Cumulative Effects.** A cumulative effect is identified for prey availability, and the effect is considered insignificant since the combination of internal and external removals of prey is not expected to decrease prey availability such that the sablefish stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.2, any habitat-mediated impacts would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, it is determined that the FMP would have insignificant effects on sablefish habitat suitability (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects identified for sablefish include past foreign, JV, and domestic fisheries, the State of Alaska crab and bait fisheries, IPHC longline, and climate changes and regime shifts (see Sections 3.5.1.3 and 3.5.1.17). Past fishing for Sablefish in the past fisheries likely disrupted habitat in areas of the GOA and possibly the BSAI. It is possible that some of these areas have not recovered (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, effects are possible from the State of Alaska fisheries, and the IPHC fishery since any of these may impact bottom

habitat through use of fishing gear. Impacts on habitat from climate changes and regime shifts on the Sablefish stock could be beneficial or adverse and marine pollution has been identified as a potential adverse contributing factor.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, they are determined to be is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the sablefish stock to sustain itself at or above MSST is jeopardized.

4.6.1.4 Atka Mackerel

This section provides the effects analysis for BSAI and GOA Atka mackerel for each of the bookends under Alternative 2. The goal of Alternative 2 is to have a more aggressive harvesting policy while preventing overfishing of target groundfish stocks.

For further information regarding persistent past effects listed below in the text and in the tables, see the past/present effects analysis in Sections 3.5.1.4 and 3.5.1.18. Atka mackerel are managed as separate stocks in the BSAI and GOA; in the BSAI the species is managed under Tier 3a of the ABC and OFL definitions. However, in the GOA Atka mackerel are managed under Tier 6.

Direct/Indirect Effects of FMP 2.1

Model projections of future BSAI Atka mackerel catch and biomass levels under Alternative 2 assume the ABC level to equal the OFL.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Age structured models were not available for evaluation of impacts for the GOA, therefore model projections of future biomass levels were not produced. Direct/indirect effects are summarized in Table 4.6-1.

Catch and Fishing Mortality

The average expected yield for BSAI Atka mackerel for the period 2003-2007 is 73,300 mt (Table H.4-17 of Appendix H). The catch and ABC values, which are equivalent in the projections, are expected to decrease through 2006. The average fishing mortality imposed on the BSAI Atka mackerel stock in 2002 is 0.251. Model projections show this value will increase to 0.564 in 2003, and remain at that level through 2007. The fishing mortality rate under FMP 2.1 (0.564) is equivalent to the F_{MSY} proxy ($F_{35\%}$) which is the rate associated with the OFL. Overall, the projections show a 125 percent increase in the average fishing mortality rate from 2002 to 2007.

Under the specifications of the projection model, no new fisheries could be developed that were not present during the time period 1997-2001. The current GOA ABC and TAC level is 600 mt. This low level of TAC is intended to preclude a directed fishery and only provide for bycatch in other fisheries. This harvest strategy has been applied to GOA Atka mackerel since 1997. Under FMP 2.1, the ABC for GOA Atka mackerel would be set equal to the OFL of 6,200 mt. At this harvest level, it is likely that a fishery for GOA Atka mackerel would be developed; however, catches could not be projected within the model for FMP 2.1 (Table H.4-38 of Appendix H).

Total Biomass

Total (ages 1-15+) biomass of BSAI Atka mackerel at the start of 2002 is estimated to be 480,000 mt. Model projections of future total BSAI total biomasses are shown in Table H.4-17 of Appendix H. Under FMP 2.1, model projections indicate that total BSAI Atka mackerel is expected to decline to a value of 388,000 mt by 2005, then increase to a value of 410,000 mt by 2007, with a 2003-2007 average value of 412,000 mt. Overall, the projections show about a 15 percent decrease in total biomass from 2002 to 2007 under FMP 2.1.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Therefore, model projections are unable to predict future biomass levels. However, as noted above, it is likely that a fishery for GOA Atka mackerel would be developed under FMP 2.1. The likely impact of this fishery, while not modeled explicitly, is that the stock of Atka mackerel in the GOA would remain stable or decrease.

Spawning Biomass

Female spawning biomass of BSAI Atka mackerel at the start of 2002 is estimated at 118,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-17 of Appendix H and Figure H.4-11 of Appendix H. Under FMP 2.1, model projections indicate that BSAI spawning biomass is expected to decline to a value of 65,300 mt by 2005, then increase to a value of 73,700 mt by 2007, with a 2003-2007 average value of 76,500 mt. Overall, the projections show about a 38 percent decrease in female spawning biomass from 2002 to 2007 under FMP 2.1. Projected spawning biomass exceeds the proxy BMSY value ($B_{35\%}$) of 77,800 mt in 2003, but dips below the B_{MSY} value for the years 2004-2007.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Therefore, model projections are unable to predict future biomass levels. However, as noted above, it is likely that a fishery for GOA Atka mackerel would be developed under FMP 2.1. The likely impact of this fishery, while not modeled explicitly, is that the stock of Atka mackerel in the GOA would remain stable or decrease.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.1, the current network of spatial/temporal closed areas is repealed, except for the temporal/spatial closures designated in the Steller sea lion protection measures which will remain in place.

The directed fishery for Atka mackerel is prosecuted by catcher processor bottom trawlers. The patterns of the fishery generally reflect the behavior of the species in that the fishery is highly localized, occurring in the same few locations each year, at depths that typically range between 100 and 200 m. The localized pattern of fishing for Atka mackerel apparently does not affect fishing success from one year to the next since local populations in the Aleutians appear to be replenished by immigration and recruitment. In addition, the management measures which distribute TAC spatially and temporally, remain in place. That is, the overall BSAI TAC is allocated to three management areas (western, central, and Bering Sea/eastern Aleutians), and the regional TACs are further allocated to two seasons and there are limits to the amount of catch that can be taken inside of Steller sea lion critical habitat. Because Steller sea lion critical habitat overlaps significantly with Atka mackerel habitat, these measures provide protection to Atka mackerel by reducing the risk of localized depletion through effort limitations and reductions. However, under FMP 2.1 catches of BSAI Atka mackerel would increase. It is unknown whether the increased effort would be accommodated

through increased concentration of the catch or expanded exploitation in new areas, or a combination of both strategies. As such, the impacts of the spatial/temporal concentration of fishing mortality under FMP 2.1 is unknown.

Under FMP 2.1 there is the potential for development of a GOA Atka mackerel fishery and a substantial increase in fishing mortality. This could result in much higher concentrations of fishing mortality in time and space. However, it is unknown whether the potential increases in the spatial/temporal concentrations of GOA Atka mackerel catches under FMP 2.1 would affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success.

Status Determination

Model projections of future catches of BSAI Atka mackerel are equivalent to the OFL in all projection years under FMP 2.1 (Table H.4-17 of Appendix H). Female spawning biomass is above $B_{35\%}$ (B_{MSY} proxy) in 2003, thus the BSAI Atka mackerel stock is determined to be above its MSST in the year 2003. Female spawning biomass dips below $B_{35\%}$ but remains above $\frac{1}{2}B_{35\%}$ in each of the projection years 2004 to 2007. Long-term projections show that the stock does not rebuild to the $B_{35\%}$ level within 10 years of each of the projection years (2004 to 2007), therefore the BSAI Atka mackerel stock is determined to be below its MSST and overfished in the years 2004 to 2007.

GOA Atka mackerel are in Tier 6 and its MSST is unknown; therefore a status determination cannot be made.

Age and Size Composition

Under FMP 2.1, the mean age of BSAI Atka mackerel in 2007, as computed in model projections, is 2.61 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.82 years. Note that the mean ages and sizes actually observed in 2007 (as opposed to the model projections of mean age in 2007) will be driven largely by the strengths of incoming recruitments during the intervening years. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of its being a fished population with a greater than 30-year catch history. In the short-term, the impacts of the current fishing mortality levels on the stock would be overshadowed by the magnitude of incoming year-classes, which in turn are highly dependent on environmental conditions. The cumulative long-term impacts of the fishing mortality rates could cause a shift in the age and size compositions.

It is unknown what the actual level of GOA Atka mackerel catch would be under FMP 2.1. Although it is thought that changes in the age and size compositions of GOA Atka mackerel are more likely to be driven by variation in recruitment than to the effects of fishing, there is the potential for a substantial increase in fishing mortality under FMP 2.1 which could impact the age and size compositions in the short-term.

Sex Ratio

A 50:50 sex ratio is assumed for the BSAI Atka mackerel stock assessment and model projections. It is unknown what the true population sex ratio is, and what change, if any, would occur in the future. The current population sex ratio of GOA Atka mackerel is unknown. The true GOA population sex ratio, and what changes, if any, would occur in the future are unknown.

Habitat Suitability

Because Steller sea lion critical habitat overlaps significantly with Atka mackerel habitat, Steller sea lion protection measures may provide habitat protection for Atka mackerel through effort limitations and reductions. However, under FMP 2.1 catches of BSAI Atka mackerel would increase. It is unknown whether the increased effort would be accommodated through increased concentration of the catch or expanded exploitation in new areas, or a combination of both strategies. It is unknown whether the level of habitat disturbance caused by the fishery under FMP 2.1 would be sufficient to affect the sustainability of the stock through a decrease in reproductive success. As such, the impacts to habitat suitability under FMP 2.1 are unknown.

Under FMP 2.1 there is the potential for development of a GOA Atka mackerel fishery and a substantial increase in fishing mortality. It is likely that the increased effort would be accommodated through increased concentration of the catch and expanded exploitation in new areas. It is unknown whether the level of habitat disturbance caused by the fishery under FMP 2.1 would be sufficient to affect the sustainability of the stock through a decrease in reproductive success. As such, the impacts to habitat suitability under FMP 2.1 are unknown.

Predation-Prey Relationships

The trophic interactions of Atka mackerel are governed by a complex web of indirect interactions that are currently difficult to quantify. Higher catches of Atka mackerel could impact the amount of Atka mackerel available to the ecosystem. Under FMP 2.1, fewer commercial-sized Atka mackerel would be available as prey and predators in the ecosystem. In a study conducted by Yang (1996), more than 90 percent of the total stomach contents weight of Atka mackerel in the study was made up of invertebrates, with less than 10 percent made up of fish. Based on the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 2.1 will not impact prey availability for BSAI and GOA Atka mackerel. Overall however, information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1.

Summary of Effects of FMP 2.1 – Atka Mackerel

The criteria used to estimate the significance of impacts of the FMPs on the BSAI and GOA stock of Atka mackerel are outlined in Section 4.1.1.1. The ratings of conditionally significant (either beneficial or adverse) are not applicable in this analysis as the model projections yielded results that were deemed either significant (beneficial or adverse), insignificant, or unknown.

The ratings use the overfishing mortality rate (F_{OFL}) and the MSST for the fishing mortality effect and the MSST for all other effects, as a basis for the beneficial or adverse impacts of FMP 2.1. Because the mean projected BSAI Atka mackerel fishing mortality rates are equal to the overfishing mortality rate for the projection years 2003-2007, the overfishing aspect of the fishing mortality effect is insignificant for Alternative 2.1. The spawning stock biomass of BSAI Atka mackerel in 2003 is above $B_{35\%}$ (B_{MSY} proxy), thus the BSAI Atka mackerel stock is determined to be above its MSST for the year 2003 under FMP 2.1. However, the BSAI Atka mackerel stock is determined to be below its MSST and overfished in the years 2004 to 2007. Thus, the impact of the change in biomass aspect of the fishing mortality effect is determined to be significantly adverse. Although the BSAI Atka mackerel stock is determined to be below its MSST in the years 2004 to 2007, it is unknown whether the potential increases in the spatial/temporal concentrations

of BSAI Atka mackerel catches under FMP 2.1 would affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success. Therefore the impact of the spatial temporal concentration of the catch is unknown. Based on the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 2.1 will not impact prey availability for BSAI Atka mackerel and the impact to the prey availability effect is determined to be insignificant. Because it is unknown whether the level of habitat disturbance caused by the fishery under FMP 2.1 would be sufficient to affect the sustainability of the BSAI Atka mackerel stock through a decrease in reproductive success, the impact to habitat suitability under FMP 2.1 is determined to be unknown.

Relative to the comparative baseline, under FMP 2.1, the BSAI Atka mackerel stock is overfished. Spawning biomass declines through 2005, after which biomass increases. Long-term (10 and 20 year) projections of spawning biomass show a very stable trend in biomass after 2007, with levels just below the $B_{35\%}$ level of 77,800 mt.

The fishing mortality rate and the MSST for GOA Atka mackerel are unknown, thus the effect of fishing mortality is unknown under FMP 2.1. As the MSST cannot be estimated for GOA Atka mackerel which are in Tier 6, the significance of the spatial temporal concentration and habitat suitability effects is also unknown under FMP 2.1. Although the MSST cannot be estimated for GOA Atka mackerel, due to the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 2.1 will not impact prey availability for GOA Atka mackerel, and the impact to prey availability is determined to be insignificant.

Relative to the comparative baseline, under FMP 2.1, the GOA Atka mackerel stock is likely to remain at low and possibly decreased abundance. There is the potential for a directed fishery to develop for GOA Atka mackerel.

Cumulative Effects of FMP 2.1 – BSAI Atka Mackerel

External effects and the resultant cumulative effects associated with FMP 2.1 for BSAI Atka mackerel are depicted on Table 4.5-6.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Atka mackerel stock is insignificant under FMP 2.1 (see Section 4.6.1.4).

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the BSAI Atka mackerel stock. While large removals of Atka mackerel did occur in the past, there does not appear to be a lingering effect on the BSAI Atka mackerel populations (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as the only external event that could cause effects on the BSAI Atka mackerel population. Acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.1 is identified for mortality of BSAI Atka mackerel and the effect is judged to be insignificant. Fishing effort would not exceed the OFL and

the stock is above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Atka mackerel stock is expected to be significantly adverse under FMP 2.1 (see Direct/Indirect Effects).

- **Persistent Past Effects.** While past large removals of Atka mackerel and other past effects on biomass have been identified (see Section 3.5.1.4), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality, and therefore would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified under FMP 2.1. The effect is judged to be significantly adverse. Due to the internal effects of the FMP, biomass of the BSAI stock is projected to fall below the MSST from 2004 to 2007. The additional mortality from external human controlled events will likely cause additional reduction in biomass.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** It is unknown whether the potential increases in the spatial/temporal concentrations of BSAI Atka mackerel catches under FMP 2.1 would affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success (see Direct/Indirect Effects).

- **Persistent Past Effects.** Since the Atka mackerel fishery was highly localized, past foreign, JV, and domestic fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. However, the effect of this change in distribution on genetic structure is unknown. Past commercial whaling and sealing also removed large predators of Atka mackerel adding to the potential for reproductive success of the stock. Lingering past effects are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts could have potential beneficial or potential adverse effects on Atka mackerel reproductive success. A shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the significance of the effect is unknown since it is not known how the changes in spatial/temporal concentration of the fishery under the FMP would affect the sustainability of the stock.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, the effect is judged insignificant (see Direct/Indirect Effects).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of Atka mackerel prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Atka mackerel prey species (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Climate changes and regime shifts could have potential beneficial or potential adverse effects on Atka mackerel reproductive success. A shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** Cumulative effects are identified for prey availability and the effect is insignificant since the combination of internal and external removals of prey species is not expected to decrease prey availability such that the Atka mackerel stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** It is unknown whether the level of habitat disturbance caused by the fishery under FMP 2.1 would be sufficient to affect the sustainability of the stock (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects identified for BSAI Atka mackerel stocks include past foreign, JV, domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.4). Intense bottom trawling for Atka mackerel in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Impacts on habitat from the climate changes and regime shifts could be either beneficial or adverse. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, its significance on the BSAI Atka mackerel stock is unknown.

Direct/Indirect Effects of FMP 2.2

Model projections of future BSAI Atka mackerel catch and biomass levels under FMP 2.2 assume the maximum permissible fishing mortality rate according to Amendment 56 ABC/OFL definitions.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Age structured models were not available for evaluation of impacts for the GOA; therefore model projections of future biomass levels were not produced. Direct/indirect effects are summarized in Table 4.6-1.

Catch and Fishing Mortality

The average expected yield for BSAI Atka mackerel for the period 2003-2007 is 63,400 mt. The catch and ABC values, which are equivalent in the projections, are expected to decrease through 2006. The average fishing mortality imposed on the BSAI Atka mackerel stock in 2002 is 0.251. Model projections show this value will increase to 0.447 in 2003, decrease to 0.387 by 2005, then increase to 0.406 in 2007. Overall, the projections show a 62 percent increase in the average fishing mortality rate from 2002 to 2007. These values are well below the F_{MSY} proxy value of 0.564 which is the rate associated with the OFL (Table H.4-17 of Appendix H).

Projections of GOA Atka mackerel under FMP 2.2 indicate that catches will likely average 300 mt through 2007 (Table H.4-38 of Appendix H). Annual changes in the GOA Atka mackerel catches reflect shifts in catches of other species which catch Atka mackerel as bycatch (e.g. Pacific ocean perch, pollock, northern rockfish, and Pacific cod).

Total Biomass

Total (ages 1-15+) biomass of BSAI Atka mackerel at the start of 2002 is estimated to be 480,000 mt. Model projections of future total BSAI total biomasses are shown in Table H.4-17 of Appendix H. Under FMP 2.2, model projections indicate that total BSAI Atka mackerel is expected to decline to a value of 412,000 mt by 2005, then increase to a value of 442,000 mt by 2007, with a 2003-2007 average value of 432,000 mt. Overall, the projections show an 8 percent decrease in total biomass from 2002 to 2007 under FMP 2.2.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Therefore, model projections are unable to predict future biomass levels.

Spawning Biomass

Female spawning biomass of BSAI Atka mackerel at the start of 2002 is estimated at 118,500 mt. Model projections of future BSAI spawning biomasses are shown in Table H.4-17 of Appendix H. Under FMP 2.2, model projections indicate that BSAI spawning biomass is expected to decline to a value of 77,700 mt by 2005, then increase to a value of 87,600 mt by 2007, with a 2003-2007 average value of 87,600 mt. Overall, the projections show a 26 percent decrease in female spawning biomass from 2002 to 2007 under FMP 2.2. Projected spawning biomass dips slightly below the proxy BMSY value of 77,800 mt in 2005, but otherwise exceeds the B_{MSY} value for the projection years 2003-2007.

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Therefore, model projections are unable to predict future biomass levels.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.2, the current network of spatial/temporal closed areas is in place. The closures designated in the Steller sea lion protection measures probably have the largest impact relative to Atka mackerel.

The directed fishery for Atka mackerel is prosecuted by catcher processor bottom trawlers. The patterns of the fishery generally reflect the behavior of the species in that the fishery is highly localized, occurring in the same few locations each year, at depths that typically range between 100 and 200 m. The localized pattern of fishing for Atka mackerel apparently does not affect fishing success from one year to the next since local populations in the Aleutians appear to be replenished by immigration and recruitment. In addition, management measures would be in place that have the effect of spreading out the harvest in time and space. The overall BSAI TAC would be allocated to three management areas (western, central, and Bering Sea/eastern Aleutians). The regional TACs would be further allocated to two seasons and there would be limits to the amount of catch that can be taken inside of Steller sea lion critical habitat. Because Steller sea lion critical habitat overlaps significantly with Atka mackerel habitat, these measures provide protection to Atka mackerel by reducing the risk of localized depletion through effort limitations and reductions. The temporal/spatial concentration of the catch under FMP 2.2 does not appear to affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST.

Status Determination

Model projections of future catches of BSAI Atka mackerel are below the OFL in all years under FMP 2.2 (Table H.4-17 of Appendix H). Female spawning biomass is above $B_{35\%}$ (B_{MSY} proxy) in 2003-2004 and 2006-2007. Female spawning biomass dips slightly below $B_{35\%}$ in 2005, but rebuilds to the $B_{35\%}$ level by the following year, therefore the BSAI Atka mackerel stock is determined to be above its MSST and is not overfished under FMP 2.2.

GOA Atka mackerel are in Tier 6 and the stock's MSST is unknown; therefore a status determination cannot be made.

Age and Size Composition

Under FMP 2.2, the mean age of BSAI Atka mackerel in 2007, as computed in model projections, is 2.73 years. This compares with a mean age in the equilibrium unfished BSAI stock of 3.82 years. Note that the mean ages and sizes actually observed in 2007 (as opposed to the model projections of mean age in 2007) will be driven largely by the strengths of incoming recruitments during the intervening years. The selectivity of the fishery has cumulative impacts on the age composition due to fishing mortality, and the current composition is also the result of its being a fished population with a greater than 30-year catch history. In the short-term however, the impacts of the current fishing mortality levels on the stock would be overshadowed by the magnitude of incoming year-classes, which in turn are highly dependent on environmental conditions. The cumulative long-term impacts of the fishing mortality rates could cause a shift in the age and size compositions.

The level of catch of GOA Atka mackerel is low and projected to remain at a low level, therefore, it is unlikely that the age and size compositions would change in the future under FMP 2.2. Changes in the age and size compositions of GOA Atka mackerel are more likely driven by variation in recruitment than to the effects of fishing.

Sex Ratio

A 50:50 sex ratio is assumed for the BSAI Atka mackerel stock assessment and model projections. It is unknown what the true population sex ratio is, and what change, if any, would occur in the future. The current population sex ratio of GOA Atka mackerel is unknown. The true GOA population sex ratio, and what changes, if any, would occur in the future are unknown.

Habitat Suitability

Because Steller sea lion critical habitat overlaps significantly with Atka mackerel habitat, Steller sea lion protection measures may provide habitat protection for Atka mackerel through effort limitations and reductions. The level of habitat disturbance caused by the fishery under FMP 2.2, is not likely to affect the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST.

Predator/Prey Relationships

The trophic interactions of Atka mackerel are governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.2. In a study conducted by Yang (1996), more than 90 percent of the total stomach contents weight of Atka mackerel in the study was made up of invertebrates, with less than 10 percent made up of fish. Based on the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 2.2 will not impact prey availability for BSAI and GOA Atka mackerel.

Summary of Effects of FMP 2.2 – Atka Mackerel

The criteria used to estimate the significance of impacts of the FMPs on the BSAI and GOA stock of Atka mackerel are outlined in Section 4.1.1.1. The ratings of conditionally significant (either beneficial or adverse) are not applicable in this analysis as the model projections yielded results that were deemed either significant (beneficial or adverse), insignificant, or unknown.

The ratings use the overfishing mortality rate (F_{OFL}) and the MSST for the fishing mortality effect and the MSST for all other effects, as a basis for the beneficial or adverse impacts of FMP 2.2. Because the mean projected BSAI Atka mackerel fishing mortality rates are below the overfishing mortality rate, and the spawning stock is above its MSST in each of the projection years (2003-2007), the fishing mortality effect is insignificant for FMP 2.2. As noted above, the BSAI Atka mackerel stock is determined to be above its MSST under FMP 2.2. Thus, for all other effects, it was determined that FMP 2.2 did not jeopardize the ability of the BSAI Atka mackerel stock to sustain itself at or above its MSST, therefore the effects were insignificant.

Relative to the comparative baseline, under FMP 2.2, the BSAI Atka mackerel stock is not overfished. Spawning biomass declines through 2005, after which biomass increases. Long-term projections (10 and 20

year projections) of spawning biomass show a very stable trend in biomass after 2007, with levels similar to the 2007 level of 87,600 mt.

The fishing mortality rate and the MSST for GOA Atka mackerel are unknown, thus the effect of fishing mortality is unknown under FMP 2.2. As the MSST cannot be estimated for GOA Atka mackerel which are in Tier 6, the significance of the spatial temporal concentration and habitat suitability effects are also unknown under FMP 2.2. Although the MSST cannot be estimated for GOA Atka mackerel, due to the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 2.2 will not impact prey availability for BSAI Atka mackerel and the impact to the prey availability effect is determined to be insignificant.

Relative to the comparative baseline, under FMP 2.2, the GOA Atka mackerel stock is likely to remain at a low abundance under continued low exploitation as a bycatch fishery only.

Cumulative Effects of FMP 2.2

External effects and the resultant cumulative effects associated with FMP 2.2 are shown in Tables 4.5-6.

BSAI Atka Mackerel

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Atka mackerel stock is insignificant under FMP 2.2 (see Section 4.6.1.4). Overall, the projections show a 62 percent increase in the average fishing mortality rate from 2002 to 2007. These values are well below the F_{MSY} proxy value of 0.564 which is the rate associated with the OFL.

- **Persistent Past Effects.** Past effects of the foreign, JV, and domestic fisheries are not expected for the BSAI Atka mackerel stock. While large removals of Atka mackerel did occur in the past, there does not appear to be a lingering effect on the BSAI Atka mackerel populations (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as the only external event that could cause effects on the BSAI Atka mackerel population. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.2 is identified for mortality of BSAI Atka mackerel, and the effect is judged to be insignificant. Atka mackerel are fished at less than the OFL and are above the minimum stock size. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Atka mackerel stock is expected to be insignificant under FMP 2.2 (see Direct/Indirect Effects).

- **Persistent Past Effects.** While past large removals of Atka mackerel and other past effects on biomass have been identified (see Section 3.5.1.4), these do not appear to have had a lingering effect on the ability of the stock to sustain itself above the MSST.

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1 in the BSAI, marine pollution is identified as having a reasonably foreseeable potential adverse contribution to change in biomass, and climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality, and therefore would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified and the effect is insignificant since the combination of internal and external factors is not expected to sufficiently reduce the Atka mackerel biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The temporal/spatial concentration of the catch under the FMP does not appear to affect the sustainability of the stock either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST and the impact is judged insignificant (see Direct/Indirect Effects).

- **Persistent Past Effects.** As discussed for FMP 2.1, past foreign, JV, and domestic fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. Also, since past fisheries could have had a beneficial effect on Atka mackerel recruitment by reducing the adult Atka mackerel biomass, lingering beneficial effects are identified for change in reproductive success. In addition, past commercial whaling and sealing also removed large predators of Atka mackerel adding to the potential for reproductive success of the stock. Lingering past effects are also identified due to Climate Changes and Regime Shifts (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, marine pollution could contribute adversely to genetic changes and reduced recruitment, and climate changes and regime shifts could have potential beneficial or potential adverse effects on Atka mackerel reproductive success.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration, and the effect is insignificant since the combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Any predation-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, the effect is judged insignificant (see Direct/Indirect Effects).

- **Persistent Past Effects.** While lingering population level effects from past foreign and domestic fisheries catch and bycatch of Atka mackerel prey species are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Atka mackerel prey species (see Section 3.5.1.4).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, climate changes and regime shifts could have potential beneficial or potential adverse effects on Atka mackerel reproductive success. Marine pollution has been identified as a reasonably foreseeable future adverse contributing factor.

- **Cumulative Effects.** Cumulative effects are identified for prey availability, and the effect is insignificant since the combination of internal and external removals of prey species is not expected to decrease prey availability such that the Atka mackerel stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The level of habitat disturbance caused by the fishery under FMP 2.2, does not appear to affect the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST, and the effect is judged insignificant (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects identified for BSAI Atka mackerel stocks include past foreign, JV, and domestic fisheries, and climate changes and regime shifts (see Section 3.5.1.4) Intense bottom trawling for Atka mackerel in the past fisheries likely disrupted habitat in areas of the BSAI. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As discussed under FMP 2.1, impacts on habitat from the climate changes and regime shifts could be either beneficial or adverse. Marine pollution has been identified as a potential adverse contributing factor.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Atka mackerel stock to sustain itself at or above MSST is jeopardized.

Cumulative Effects of FMP 2.1 and FMP 2.2 – GOA Atka Mackerel

GOA Atka mackerel are managed in Tier 6 because current estimates of total and spawning biomass are unknown for GOA Atka mackerel. Age structured models were not available for evaluation of impacts for the GOA, therefore model projections of future biomass levels were not produced. Therefore, the internal effects of the FMPs are unknown for all categories with the exception of prey availability. In addition, the external effects and cumulative effects are the same for each FMP. Cumulative effects are summarized in Table 4.5-7.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Atka mackerel stock is unknown under FMP 2.1 and FMP 2.2. The fishing mortality rate and the MSST for GOA Atka mackerel are unknown, thus the effect of fishing mortality is unknown under both FMP.

- **Persistent Past Effects.** Past effects of the past foreign, JV, and domestic, fisheries are likely for the GOA Atka mackerel stock. Large, concentrated removals of Atka mackerel occurred in the foreign, domestic, and JV fisheries, and have had a lingering effect on the GOA Atka mackerel population, which has not yet recovered (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the population is jeopardized. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality.

- **Cumulative Effects.** A cumulative effect under FMP 2.1 and FMP 2.2 is identified for mortality of GOA Atka mackerel, but the significance of the effect is unknown. GOA Atka mackerel are in Tier 6 and the stock's MSST is unknown; therefore a status determination cannot be made.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Atka mackerel stock is unknown under FMP 2.1 and FMP 2.2. Current reliable estimates of total and spawning biomass are unknown for GOA Atka mackerel.

- **Persistent Past Effects.** Persistent effects of the past foreign, JV, and domestic fisheries are likely for the GOA Atka mackerel stock. Large, concentrated removals of Atka mackerel occurred in the foreign, domestic, and JV fisheries, and have had a lingering effect on the GOA Atka mackerel population, which has not yet recovered (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as having a potential adverse contribution to change in biomass since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the population is affected. Climate changes and regime shifts are not identified as being contributors to Atka mackerel mortality, thereby would not directly affect biomass.

- **Cumulative Effects.** A cumulative effect for change in biomass is identified under FMP 2.1 and FMP 2.2, however, the significance of the effect is unknown.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As the MSST cannot be estimated for GOA Atka mackerel, which are in Tier 6, the significance of the spatial temporal concentration effects is also unknown under both FMP.

- **Persistent Past Effects.** Since the Atka mackerel fishery was highly localized, past foreign, JV, and domestic fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. However, the effect of this change in distribution on genetic structure is unknown. The past highly localized fisheries are found to have had lingering effects on the spatial/temporal distribution of the fish. Also, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects.** Marine pollution could contribute adversely to genetic changes and reduced recruitment since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Also, climate changes and regime shifts could impact spawning success since a shift toward colder waters favors recruitment and survival of Atka mackerel. Conversely, warmer waters are potentially adverse.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration; however, the significance of the effect is unknown.

Change in Prey Availability

- **Direct/Indirect Effects.** Although the MSST cannot be estimated for GOA Atka mackerel, due to the low proportion of fish found in the diet of Atka mackerel, it is presumed that FMP 2.1 and FMP 2.2 will not impact prey availability for BSAI Atka mackerel. The impact to prey availability is determined to be insignificant.

- **Persistent Past Effects.** While lingering population level effects on the invertebrate prey of Atka mackerel from past foreign, state, and domestic fisheries, and the effects of EVOS on these species, are not expected, past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Atka mackerel prey species (see Section 3.5.1.18).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Atka mackerel prey species could be either beneficial or adverse depending on the direction of change. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** Cumulative effects are identified for prey availability; however, the effect is unknown since the direction of external effects is unknown.

Change in Habitat Suitability

- **Direct/Indirect Effects.** As the MSST cannot be estimated for GOA Atka mackerel which are in Tier 6, the significance of the habitat suitability effects is also unknown under FMP 2.1.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA Atka mackerel stocks include past foreign, JV, and domestic fisheries, EVOS, and climate changes and regime shifts (see Section 3.5.1.18). Intense bottom trawling for Atka mackerel in the past fisheries likely disrupted

habitat in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** Impacts on habitat from climate changes and regime shifts on the GOA Atka mackerel could be either favorable or unfavorable depending on the direction of change. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for habitat suitability; however, its significance on the GOA Atka mackerel stock is unknown.

4.6.1.5 Yellowfin Sole and Shallow Water Flatfish

Numerous fishery management actions have been implemented that affect the yellowfin sole fisheries in the BSAI. These actions are described in more detail in Section 3.5.1.5 of this SEIS. Yellowfin sole is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species by the National Standard Guidelines.

Eight flatfish species inhabit shallow waters and are managed in the shallow water flatfish assemblage in the GOA. They include: northern and southern rock sole, yellowfin sole, starry flounder, butter sole, English sole, Alaska plaice and sand sole. Survey results from 2001 indicate that over half of the estimated biomass (54 percent) of this assemblage are northern and southern rock sole. The shallow water group is managed as a Tier 4 and Tier 5 species in the GOA (Turnock *et al.* 2001).

For further information regarding persistent past effects listed below in the text and in these tables (see Sections 3.5.1.5 and 3.5.1.19).

BSAI Yellowfin Sole – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Direct/indirect effects are summarized in Table 4.6-1.

Total Biomass

The total biomass of yellowfin sole at the start of 2002 is estimated to be 1,552,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-4 of Appendix H. Under FMP 2.1, model projections indicate that the total BSAI biomass is expected to decline more than 12 percent of the 2002 value to 1,361,000 mt by 2007, with a 2003-2007 average value of 1,435,000 mt. Under FMP 2.2, model projections indicate that the total BSAI biomass is expected to decline about 8 percent of the 2002 value to 1,420,000 mt by 2007, with a 2003-2007 average value of 1,467,000 mt.

Spawning Biomass

Spawning biomass of female yellowfin sole at the start of 2002 is estimated to be 450,700 mt. Model projections of future yellowfin sole spawning biomass estimates are shown in Table H.4-4 of Appendix H and Figure H.4-3 of Appendix H. Under FMP 2.1, model projections indicate that female spawning biomass is expected to decline more than 25 percent of the 2002 value to 337,100 mt by 2007, with a 2003-2007

average value of 386,700 mt. Projected female spawning biomass is estimated to remain above the BMSY proxy value of 336,900 mt by the end of the five year projection.

Under FMP 2.2, model projections indicate that female spawning biomass is expected to decline 19 percent of the 2002 value to 364,900 mt by 2007, with a 2003-2007 average value of 402,500 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 336,900 mt throughout the five year projection.

Fishing Mortality

The average annual fishing mortality imposed on the yellowfin sole stock in 2002 is 0.064. Under FMP 2.1, model projections show this value will increase each year starting in 2004 ending at 0.138 in 2007. Under this FMP fishing mortality is at, but does not exceed, the F_{MSY} proxy value in 2007 (Table H.4-4 of Appendix H).

Under FMP 2.2, model projections show that this value will be 0.115 for 2003-2005 and decrease to 0.109 by 2007. This maximum value under this FMP is less than the F_{MSY} proxy value of 0.138, the rate associated with the OFL (Table H.4-4 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual BSAI yellowfin sole harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed (Walrus Island, Red King crab savings area, etc.), or areas they previously avoided due to high bycatch rates.

Since FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that yellowfin sole fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual BSAI yellowfin sole harvest would not be affected under FMP 2.2.

Status Determination

Model projections of future catches of BSAI yellowfin sole are at (but do not exceed) the OFLs in 2003-2007 under FMP 2.1 and FMP 2.2. Female spawning biomass is above the MSST level in 2003-2007, as it was in the 2002 baseline year.

Age and Size Composition

Under FMP 2.1, the mean age of the BSAI yellowfin sole stock in 2008, as computed in model projections (Table H.4-4 of Appendix H), is 5.9 years. Under FMP 2.2, the mean age of the BSAI yellowfin sole stock in 2008, as computed in model projections (Table H.4-4 of Appendix H), is 6.1 years. This compares with a mean age in the equilibrium unfished BSAI stock of 8.0 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of yellowfin sole in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on yellowfin sole would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 or FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – BSAI Yellowfin Sole

Table 4.6-1 summarizes the effects of FMP 2.1 and FMP 2.2 on BSAI yellowfin sole. The rating of conditionally significant (either beneficial or adverse) is not applicable in this analysis as the model projections yielded results that were determined either significant (beneficial or adverse), insignificant, or unknown.

The ratings utilize FOFL and the MSST as a basis for beneficial or adverse impacts on fishing mortality and changes in reproductive success for each FMP. A thorough description of the rationale for the MSST can be found in the National Standard Guidelines 50 CFR Part 600 (FR Vol. 63, No. 84, 24212-24237). Under FMP 2.1 and FMP 2.2, the spawning stock biomass of BSAI yellowfin sole is expected to be above the MSST throughout the five year projection. Since the fishing mortality rate does not exceed FOFL and the stock is projected to remain above the MSST, the expected changes under these FMPs are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under these FMPs are considered insignificant.

Relative to the 2002 comparative baseline, the yellowfin sole stock is projected to continue to not be overfished under these FMPs. The 20 year projection indicates that the female spawning stock is expected to decline until 2010 to below B_{MSY} levels and will increase thereafter through the end of the projection to about the B_{MSY} level in 2023.

Cumulative Effects of FMP 2.1 and FMP 2.2

External effects and the resultant cumulative effects associated with FMP 2.1 and FMP 2.2 are shown in Table 4.5-8.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI yellowfin sole is rated as insignificant under FMP 2.1 and FMP 2.2 (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI yellowfin sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause yellowfin sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of yellowfin sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI yellowfin sole, but is rated as insignificant. Fishing mortality at projected levels is at, but do not exceed the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** It is not expected that FMP 2.1 or FMP 2.2 will result in an significant effect on yellowfin sole (see Section 4.6.1.5).

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI yellowfin sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause yellowfin sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse contributions on the yellowfin sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts (see Section 3.5.1.5 and 3.10).

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI yellowfin sole and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock and the spawning biomass is above the BMSY value. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI yellowfin sole catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of yellowfin sole due to climate changes and regime shifts are potentially beneficial or adverse as described above for change in biomass. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI yellowfin sole.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the yellowfin sole catch and this effect is ranked as insignificant. The spatial/temporal distribution of yellowfin sole catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the BSAI yellowfin sole is ranked as insignificant (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the BSAI yellowfin sole stock and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted (see Section 3.5.1.5 and 3.10).

- **Reasonably Foreseeable Future External Effects.** As described for change in biomass, effects of climate changes and regime shifts on the BSAI yellowfin sole stock are potentially beneficial or adverse. Marine pollution has been identified as having a potential adverse contribution since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** Cumulative effects are identified for change in prey availability; however, these effects are considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the BSAI yellowfin sole is ranked as insignificant (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects are identified for BSAI yellowfin sole include climate changes and regime shifts. In the past, when the Aleutian Low was strong and water temperatures warm, catch tended to be dominated by flatfish species, implying increased recruitment. In contrast, when the Aleutian Low was weak and water temperatures cooler, catch tended to be dominated by shrimp. Persistent past effects of the foreign, JV, and domestic fisheries gear impacts are described in Section 3.5.1.5 and Section 3.6.

- **Reasonably Foreseeable Future External Effects.** As described for change in biomass, climate changes and regime shifts on the BSAI yellowfin sole stock are potentially beneficial or adverse. Marine pollution has also been identified as a potential adverse contribution since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** Cumulative effects are identified for BSAI yellowfin sole habitat suitability and these effects are considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the yellowfin sole stock to sustain itself at or above the MSST is jeopardized.

GOA Shallow Water Flatfish – Direct/Indirect Effects of FMP 2.1and FMP 2.2

Direct/indirect effects are summarized in Table 4.6-1.

Total Biomass and Spawning Biomass

Estimates of total and spawning biomass are not available for the GOA shallow water flatfish species.

Fishing Mortality

The catch of GOA shallow water flatfish in 2002 was estimated to be 6,800 mt. Model projections of future catch are shown in Table H.4-27 of Appendix H. Under FMP 2.1, model projections indicate that the catch is expected to decrease from the 2002 value to 1,200 mt in 2003 and then increase gradually to 1,400 mt in 2006 and 2007. The 2003-2007 average catch is 1,300 mt (20 percent of the 2002 catch). Under FMP 2.2, model projections indicate that the catch is expected to decrease from 6,000 mt in 2003 to 5,000 mt in 2007. The 2003-2007 average catch is 5,600 mt.

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual GOA shallow water flatfish harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed, or areas they previously avoided due to high bycatch rates.

Because FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that GOA shallow water flatfish fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual GOA shallow water flatfish harvest would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

The available information for flatfish species in the shallow water complex requires that they are classified into either the Tier 4 or Tier 5 management category. As a result, no MSSTs are defined for these species in the National Standard Guidelines. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition projections are not available for the GOA shallow water flatfish species.

Sex Ratio

The sex ratio of shallow water flatfish in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on shallow water flatfish would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1and FMP 2.2 – GOA Shallow Water Flatfish

The direct and indirect effects of FMP 2.1 and FMP 2.2 on GOA shallow water flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks is over the five year projection and what level of fishing mortality corresponds to the modeled catch estimated under this FMP (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

External effects and the resultant cumulative effects associated with FMP 1 are shown in Table 4.5-9.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA shallow water flatfish is rated as insignificant under FMP 2.1 and FMP 2.2 (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past JV and domestic fisheries have been identified as having lingering past adverse effects on the GOA shallow water flatfish complex (see Section 3.5.1.19).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause shallow water flatfish species mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shallow water flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor since shallow water flatfish species bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA shallow water flatfish, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** Since the total and spawning biomass estimates for GOA shallow water species is unavailable, the effects of FMP 2.1 and FMP 2.2 on change in biomass is unknown.

- **Persistent Past Effects.** The past JV and domestic fisheries are identified as having past lingering adverse effects on the biomass levels of GOA shallow water flatfish (see Section 3.5.1.19).

- **Reasonably Foreseeable Future External Events.** Future external effects on mortality are indicated due to the potential adverse contributions of marine pollution since acute and/or chronic pollution events could cause shallow water flatfish species mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse contributions on the shallow water flatfish species biomass level. For more information on climate changes and regime shifts (see Sections 3.5.1.19 and 3.10). The State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of shallow water flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for change in biomass of GOA shallow water flatfish, but is rated as unknown. Fishing mortality at projected levels is well below the OFL for this stock. It is unknown if the combined effects of internal removals and removals are likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal distribution of the annual GOA shallow water flatfish harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed, or areas they previously avoided due to high bycatch rates. Because FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that GOA shallow water flatfish fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. However, little is known about the spatial/temporal characteristics of GOA shallow water flatfish, therefore the effects of FMP 2.1 and FMP 2.2 are rated as unknown.

- **Persistent Past Effects.** Past effects have not been identified for the change in genetic structure or the change in reproductive success of GOA shallow water flatfish.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of shallow water flatfish species due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse contribution, and th State of Alaska scallop fishery has been identified as a non-contributing factor to the change in genetic structure and reproductive success since bycatch of shallow water flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** Cumulative effects are possible for the change in genetic structure and reproductive success of GOA shallow water flatfish, but are rated as unknown. It is unknown if the combined effects of internal removals and removals due to reasonably foreseeable future external events are likely to jeopardize the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the GOA shallow water flatfish is determined to be unknown (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the GOA shallow water flatfish stock complex and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted (see Sections 3.5.1.19 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA shallow water flatfish stock complex are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse contribution. The State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of shallow water flatfish prey species is not expected to occur in this fishery.

- **Cumulative Effects.** Cumulative effects for change in prey availability are unknown. The predation-mediated impacts of FMP 2.1 and FMP 2.2 on shallow water flatfish are governed by a complex web of indirect interactions that are currently difficult to quantify.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the GOA shallow water flatfish complex is considered to be unknown (see Direct/Indirect Effects).

- **Persistent Past Effects.** Past effects identified for GOA shallow water flatfish include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries gear impacts are described in Section 3.5.1.19 and Section 3.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA shallow water flatfish stock complex are potential beneficial or

adverse. Marine pollution has also been identified as a potential adverse contribution. The State of Alaska scallop fishery is also identified as a potential adverse contributor to GOA shallow water flatfish habitat suitability (see Section 3.6).

- **Cumulative Effects.** Cumulative effects are identified for GOA shallow water flatfish habitat suitability; however, these effects are unknown. It is unknown if the combination of internal and external habitat disturbances will to lead to a detectable change in spawning or rearing success such that the ability of the GOA shallow water flatfish stock to maintain current population levels is jeopardized.

4.6.1.6 Rock Sole

BSAI rock sole is described in more detail in Section 3.5.1.6 of this Programmatic SEIS. Rock sole is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species.

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Direct/indirect effects are summarized in Table 4.6-1.

Total Biomass

The total biomass of rock sole at the start of 2002 is estimated to be 970,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-7 of Appendix H. Under FMP 2.1, model projections indicate that the total BSAI biomass is expected to decline 30 percent of the 2002 value to 680,000 mt by 2007, with a 2003-2007 average value of 764,000 mt. Under FMP 2.2, model projections indicate that the total BSAI biomass is expected to decline about 33 percent of the 2002 value to 645,000 mt by 2007, with a 2003-2007 average value of 744,000 mt.

Spawning Biomass

Spawning biomass of female rock sole at the start of 2002 is estimated to be 331,000 mt. Model projections of future rock sole spawning biomass estimates are shown in Table H.4-7 and Figure H.4-6 of Appendix H. Under FMP 2.1, model projections indicate that female spawning biomass is expected to decline 47 percent of the 2002 value to 176,400 mt by 2007, with a 2003-2007 average value of 237,500 mt. Projected female spawning biomass is estimated to remain above the B_{MSY} proxy value of 136,700 mt throughout the five year projection.

Under FMP 2.2, model projections indicate that female spawning biomass is expected to decline 51 percent of the 2002 value to 161,300 mt by 2007, with a 2003-2007 average value of 229,000 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 136,700 mt throughout the five year projection.

Fishing Mortality

The average annual fishing mortality imposed on the rock sole stock in 2002 is 0.055. Under FMP 2.1, model projections show this value will increase each year reaching 0.126 in 2007. Under FMP 2.2, model

projections show this value will steadily increase to 0.161 by 2007. These maximum values are less than the F_{MSY} proxy value of 0.21, the rate associated with the OFL (Table H.4-7 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual BSAI rock sole harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed (Walrus Island, red king crab savings area, etc.) or areas where they avoided because of high bycatch.

The spatial/temporal characteristics of the annual BSAI rock sole harvest could be affected under FMP 2.2 if managers adopt PSC limits proportional to the abundance levels of the bycatch species. However, it is not known how this would affect future fishing behavior in terms of avoidance of bycatch species.

Status Determination

Model projections of future catches indicate that the fishing mortality rate does not exceed the OFL and that female spawning stock size of BSAI rock sole are above the MSST levels in 2003-2007 under FMP 2.1 and FMP 2.2. The rock sole stock is also above the MSST level in 2002 baseline year.

Age and Size Composition

Under FMP 2.1, the mean age of the BSAI rock sole stock in 2008, as computed in model projections is 4.4 years. Under FMP 2.2, the mean age of the BSAI rock sole stock in 2008, as computed in model projections (Table H.4-7 of Appendix H), is 4.6 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.9 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of rock sole in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on rock sole would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – BSAI Rock Sole

Under FMP 2.1 and FMP 2.2, the spawning stock biomass of BSAI rock sole is expected to be above the MSST through 2007. Since the F_{OFL} is not exceed and the female spawning stock is currently above the MSST, the expected changes under these FMPs are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under these FMPs are considered insignificant (Table 4.6-1).

Relative to the 2002 comparative baseline, the rock sole stock is projected to continue to not be overfished under these FMPs. The 20 year projection (Figure H.4-6 of Appendix H) indicates that the female spawning stock is expected to decline until 2010 to B_{MSY} levels and will increase thereafter through the end of the projection in 2023 under FMP 2.1. Under FMP 2.2, the 20 year projection indicates that the female spawning stock is expected to decline until 2010. Beginning in 2009 it will be below the B_{MSY} level for three years before increasing to the end of the projection in 2003, exceeding the B_{ABC} level in 2015.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects are summarized in Table 4.5-10 for BSAI rock sole.

Mortality

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of fishing mortality on the BSAI rock sole is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rock sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of rock sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI rock sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effects of the fisheries on BSAI rock sole biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rock sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the rock sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts see Sections 3.5.1.6 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI rock sole, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the BSAI rock sole. Climate changes and regime shifts have been identified as having a persistent past effect on the reproductive success of BSAI rock sole. Climate changes and regime shifts and corresponding water temperature variation could affect prey availability and habitat suitability, which in combination could affect the reproductive success of the rock sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of rock sole due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI rock sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the rock sole catch, and is ranked as insignificant. The spatial/temporal distribution of rock sole catch is not expected to change significantly. The combined effect of internal removals and removals due to Reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the change in prey availability for the BSAI rock sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts. Climate changes and regime shifts and corresponding water temperature variation do effect the availability of some forage species (i.e. capelin); however, studies on benthic invertebrates have not been conducted.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI rock sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the change in habitat suitability for the BSAI rock sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI rock sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.6.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI rock sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI rock sole habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the rock sole stock to sustain itself at or above the MSST is jeopardized.

4.6.1.7 Flathead Sole

BSAI and GOA flathead sole are described in more detail in Sections 3.5.1.7 and 3.5.1.20 of this Programmatic SEIS. Flathead sole is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species. Beginning in 2002, flathead sole were managed independent of the other flatfish complex in the GOA. Until recently, flathead sole were managed under Tier 3; as of 2004 GOA flathead sole are managed under Tier 3. GOA flathead sole were modeled under the Tier 4 category for this analysis.

BSAI Flathead Sole – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total Biomass

Total biomass of BSAI flathead sole at the start of 2003 is estimated to be 513,000 mt. Model projections of future total BSAI flathead sole biomass are shown in Table H.4-8 of Appendix H. Under FMP 2.1, model projections indicate that BSAI biomass is expected to decrease to a value of 454,000 mt in 2007, with a 2003 to 2007 average value of 475,000 mt. Under FMP 2.2, model projections indicate that BSAI flathead sole

biomass is expected to decrease to a value of 477,000 mt in 2008, with a 2003-2008 average value of 485,000 mt.

Spawning Biomass

Spawning biomass of BSAI flathead sole at the start of 2003 is estimated to be 229,400 mt. Model projections of future total BSAI flathead sole biomass are shown in Table H.4-8 and Figure H.4-7 of Appendix H. Under FMP 2.1, model projections indicate that BSAI flathead sole biomass is expected to decrease to a value of 146,300 mt in 2007. The projected average biomass from 2003-2007 is 185,600 mt. Under FMP 2.2, model projections indicate that BSAI flathead sole biomass is expected to decrease to a value of 149,200 mt in 2008, with a 2003-2008 average value of 187,100 mt.

Fishing Mortality

Under FMP 2.1, the projected fishing mortality imposed on the BSAI flathead sole stock is 0.11 in 2003, and increases to 0.145 in 2007. The proportion of spawner biomass per recruit conserved under these fishing mortality rates is 63 percent in 2003 and decreases to 57 percent in 2007, with an average of 60 percent from 2003-2007 (Table H.4-8 of Appendix H).

Under FMP 2.2, the projected fishing mortality imposed on the BSAI flathead sole stock is approximately 0.099 in 2003, increasing to 0.156 in 2008. The proportion of spawner biomass per recruit conserved under these fishing mortality rates is 66 percent in 2003, increasing to 76 percent in 2005, and decreases to 57 percent in 2008, with an average of 67 percent from 2003-2008 (Table H.4-8 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 2.1 involves the resumption of fishing in a number of areas currently closed, and these areas are largely in the EBS. The projected average harvest from 2003-2008 increased to 35,300 mt, due largely to increased catch in the directed flathead sole fishery (13,960 mt, 40 percent) and the Pacific cod trawl fishery (14,320 mt, 41 percent).

Under FMP 2.2, the average projected catch from 2003-2008 is 19,200 mt, of which 6,700 mt (34 percent) occurred in the EBS shelf flathead sole fishery with the remaining harvest divided approximately evenly between the yellowfin sole, rock sole, Pacific cod, and walleye pollock fisheries.

Status Determination

Under FMP 2.1 and FMP 2.2, the ABC is set equal to the OFL, removing the buffer between these two harvest regulations. Model projections of future catches of BSAI flathead sole are below the OFL level from 2003 to 2008.

Age and Size Composition

Under FMP 2.1, the mean age of the BSAI flathead sole stock in 2008, as computed in model projections, is 4.02 years. Under FMP 2.2, the mean age of the BSAI flathead sole stock in 2008, as computed in model projections (Table H.4-8 of Appendix H), is 4.38 years. This compares with a mean age in the equilibrium unfished stock of 5.39 years.

Sex Ratio

The sex ratio of BSAI flathead sole is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 and FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under this FMP 2.1 and FMP 2.2.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – BSAI Flathead Sole

Although the ABC and OFL levels for flathead sole are equivalent under FMP 2.1, the F_{OFL} is not reduced for lower stock sizes, and the harvest of flathead sole under FMP 2.1 is increased relative to recent levels, the fishing rates on flathead sole do not exceed the $F_{40\%}$ reference point and are within accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Thus, the direct and indirect effects of FMP 2.1 on flathead sole are considered insignificant.

Because the BSAI flathead sole are fished at less than the ABC and are above the minimum stock size threshold, the direct and indirect effects under FMP 2.2 are considered insignificant. Fishing rates are lower than accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity (Table 4.6-1).

Relative to the 2002 comparative baseline, the flathead sole stock is projected to continue to not be overfished under this FMP. Under FMP 2.1, the twenty year projection (Figure H.4-7 of Appendix H) indicates that the female spawning stock expected to decrease until 2010 at which time it will be begin to steadily increase throughout the end of the projection. Under FMP 2.2, the twenty year projection indicates that the female spawning stock expected to decrease until 2009 at which time it will be begin to steadily increase throughout the end of the projection. The female spawning stock is estimated to remain above B_{ABC} throughout the projection for both FMPs.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects of BSAI flathead sole are summarized in Table 4.5-11.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI flathead sole is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of flathead sole.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI flathead sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on BSAI flathead sole biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the flathead sole biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts see Sections 3.5.1.7 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI flathead sole, but is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock and the spawning biomass is above the B_{MSY} value. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI flathead sole catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of flathead sole due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI flathead sole.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the flathead sole catch, and is ranked as insignificant. The spatial/temporal distribution of flathead sole catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the BSAI flathead sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects are not identified for the change in prey availability of the BSAI flathead sole stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the BSAI flathead sole is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI flathead sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.7.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI flathead sole habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the flathead sole stock to sustain itself at or above the MSST is jeopardized.

GOA Flathead Sole – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total and Spawning Biomass

Estimates of total and spawning biomass are currently unavailable for this species.

Fishing Mortality

The catch of GOA flathead sole in 2002 was estimated to be 2,000 mt. Model projections of future catch are shown in Table H.4-28 of Appendix H. Under FMP 2.1, model projections indicate that the catch is expected to decrease to 1,600 mt in 2003 and slowly increase to 2,400 in 2006 and 2007. The 2003-2007 average catch is estimated at 2,100 mt.

Under FMP 2.2, model projections indicate that the catch is expected to decrease to 1,600 mt in the first two years of the projections and then be at 1,500 mt in the last two years. The 2003-2007 average catch is 1,600 mt (80 percent of the 2002 catch). The average annual fishing mortality imposed on the flathead sole stock in 2002 is 0.055. Model projections show this value will increase to 0.137 in 2007. These values are well below the F_{MSY} proxy value of 0.21, the rate associated with the OFL.

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the GOA flathead sole harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed, or areas they previously avoided due to high bycatch rates.

Since FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that GOA flathead sole fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual GOA flathead sole harvest would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

The available information GOA flathead sole requires that they are classified into the Tier 4 management category. As a result, no MSSTs are defined for these species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are currently unavailable for this species.

Sex Ratio

The sex ratio of flathead sole in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on flathead sole would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – GOA Flathead Sole

The direct and indirect effects of FMP 2.1 and FMP 2.2 on GOA flathead sole cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks is over the five year projection and what level of fishing mortality corresponds to the modeled catch estimated under this FMP (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects of GOA flathead sole are summarized in Table 4.5-12.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA flathead sole is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects have been identified for fishing mortality in the GOA flathead sole stock and include past JV and domestic fisheries. Removals by these fisheries have had a lingering adverse effect on GOA flathead sole (see Section 3.5.1.20).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of flathead sole. The State of Alaska scallop fishery has also been identified as a non-contributing factor since GOA flathead sole bycatch is not expected in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA flathead sole, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonable foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in biomass level is rated as unknown since MSST is unable to be determined at this time.

- **Persistent Past Effects.** Past effects have been identified for fishing mortality in the GOA flathead sole stock and include past JV and domestic fisheries. Large removals of flathead sole by these fisheries is determined to have had a lingering effect on the GOA flathead sole stock (see Section 3.5.1.20).

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause flathead sole mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the flathead sole biomass level. For more information on climate changes and regime shifts see Sections 3.5.1.20 and 3.10. The State of Alaska scallop fishery is identified as a non-contributing factor for change in biomass level since flathead sole bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA flathead sole, but is unknown. The MSST is not able to be determined and the total and spawning biomass estimates are currently unavailable. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is unknown since the MSST is unable to be determined.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the GOA flathead sole stock. However, climate changes and regime shifts have been identified as having a beneficial or adverse effect on GOA flathead sole reproductive success see Section 3.5.1.20 for more information on the effects of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of flathead sole due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA flathead sole. The State of Alaska scallop fishery has been identified as a non-contributing factor to change

in genetic structure and change in reproductive success since GOA flathead sole bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the flathead sole catch; however, this effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain current population levels is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the GOA flathead sole is unknown.

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the GOA flathead sole stock and include climate changes and regime shifts. For more information on the effects of climate changes and regime shifts on the GOA flathead sole stock see Section 3.5.1.20.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The State of Alaska scallop fishery is identified as a potential adverse contributor to GOA flathead sole prey availability. The State of Alaska scallop fishery gear could impact flathead sole benthic prey availability and/or quality.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown. It is unknown whether the combination of internal and external removals of prey is expected to jeopardize the ability of the stock to sustain itself at current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the GOA flathead sole is unknown.

- **Persistent Past Effects.** Past effects identified for GOA flathead sole include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.20.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA flathead sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery is identified as a potential adverse contributor to GOA flathead sole habitat suitability. For information on the effects of fishery gear on EFH see Section 3.6.

- **Cumulative Effects.** A cumulative effect is identified for GOA flathead sole habitat suitability; however, this effect is unknown. It is unknown whether the combination of internal and external habitat disturbances is expected to lead to a detectable change in spawning or rearing success such that the ability of the flathead sole stock to sustain itself at current population levels.

4.6.1.8 Arrowtooth Flounder

BSAI and GOA arrowtooth flounder are described in more detail in Sections 3.5.1.8 and 3.5.1.21 of this Programmatic SEIS. Arrowtooth flounder is managed as its own stock under the BSAI and GOA groundfish FMPs under the Tier 3 management category, thus MSSTs are defined for these species.

BSAI Arrowtooth Flounder – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total Biomass

The total biomass of BSAI arrowtooth flounder at the start of 2002 is estimated to be 811,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-6 of Appendix H. Under FMP 2.1, model projections indicate that the total BSAI biomass is expected to decline 28 percent of the 2002 value to 588,000 mt by 2007, with a 2003-2007 average value of 669,000 mt. Under FMP 2.2, model projections indicate that the total BSAI biomass is expected to decline about 27 percent of the 2002 value to 594,000 mt by 2007, with a 2003-2007 average value of 673,000 mt.

Spawning Biomass

Spawning biomass of female BSAI arrowtooth flounder at the start of 2002 is estimated to be 475,900 mt. Model projections of future arrowtooth flounder spawning biomass estimates are shown in Table H.4-6 and Figure H.4-5 of Appendix H. Under FMP 2.1, model projections indicate that female spawning biomass is expected to decline 32 percent of the 2002 value to 323,500 mt by 2007, with a 2003-2007 average value of 384,000 mt. Projected female spawning biomass is estimated to remain above the B_{MSY} proxy value of 182,900 mt throughout the five year projection.

Under FMP 2.2, model projections indicate that female spawning biomass is expected to decline 31 percent of the 2002 value to 327,600 mt by 2007, with a 2003-2007 average value of 386,700 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 182,900 mt throughout the five year projection.

Fishing Mortality

The average annual fishing mortality imposed on the BSAI arrowtooth flounder stock in 2002 is 0.015. Under FMP 2.1, model projections under this FMP show this value will increase to double the 2002 baseline value in 2007. Under FMP 2.2, model projections show this value will steadily increase to 0.032 by 2007. These projected values are below the F_{MSY} proxy value (0.38), the rate associated with the OFL (Table H.4-6 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual BSAI arrowtooth flounder harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed (Walrus Island, red king crab savings area, etc.) or areas which were previously avoided because of high bycatch.

Because FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that arrowtooth flounder fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual BSAI arrowtooth flounder harvest would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

Model projections of future catches of BSAI arrowtooth flounder are below the OFL in 2004-2007 under FMP 2.1 and FMP 2.2. The BSAI arrowtooth flounder female spawning biomass is above the MSST level throughout the five year projection and in the 2002 baseline year.

Age and Size Composition

Under FMP 2.1, the mean age of the BSAI arrowtooth flounder stock in 2008, as computed in model projections, is 4.5 years. Under FMP 2.2, the mean age of the BSAI arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-6 of Appendix H), is 4.8 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.4 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

Fishery-independent resource assessment surveys in the BSAI have found that populations of arrowtooth flounder are comprised of a higher percentage of females than males. It is believed that this is a function of a higher natural mortality rate for males than females. No information is available to suggest that this would change under FMP 2.1 and FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on BSAI arrowtooth flounder would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – BSAI Arrowtooth Flounder

Under FMP 2.1 and FMP 2.2, the spawning stock biomass of BSAI arrowtooth flounder is expected to be above the MSST. Since the fishing mortality rate does not exceed F_{OFL} and the female spawning stocks are expected to remain above the MSST, the expected changes under these FMPs are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under these FMPs are considered insignificant (Table 4.6-1).

Relative to the 2002 comparative baseline, the BSAI spawning biomass is projected to continue to not be overfished under these FMPs. The 20 year projection (Figure H.4-5 of Appendix H) indicates that both female spawning stocks are expected to remain above B_{ABC} levels through the end of the projection in 2023.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for BSAI arrowtooth flounder are summarized in Table 4.5-13.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI arrowtooth flounder is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause arrowtooth flounder mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of arrowtooth flounder. The IPHC longline fishery is identified as a potential adverse contributor to BSAI arrowtooth flounder mortality since arrowtooth flounder are caught as bycatch in this fishery. Finally, the State of Alaska herring fishery is identified as a non-contributing factor to BSAI arrowtooth flounder mortality since bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for mortality of BSAI arrowtooth flounder, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on arrowtooth flounder biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the BSAI arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause arrowtooth flounder mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the arrowtooth flounder biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts see Section 3.5.1.8 and 3.10. The IPHC longline fishery has been identified as a potential adverse contributor to BSAI arrowtooth flounder biomass level since bycatch is expected to occur in this fishery. Finally, the State of Alaska herring fishery is identified as a non-contributing factor since arrowtooth flounder bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI arrowtooth flounder, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI arrowtooth flounder. Climate changes and regime shifts are identified as having had potential adverse or beneficial effects on the reproductive success of BSAI arrowtooth flounder see Section 3.5.1.8 for more information.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of arrowtooth flounder due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI arrowtooth flounder. The IPHC longline fishery is identified as a non-contributing factor to the genetic structure and reproductive success of BSAI arrowtooth flounder since the removals are not expected to be significant. The State of Alaska herring fishery is also identified as a non-contributing factor to the genetic structure and reproductive success of BSAI arrowtooth flounder since bycatch is not expected in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the arrowtooth flounder catch, and is ranked as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the BSAI arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified include the past foreign, JV, and domestic fisheries, State of Alaska groundfish fisheries, State of Alaska herring fisheries and climate changes and regime shifts (see Section 3.5.1.8).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI arrowtooth flounder stock are potential beneficial or adverse. Some forage species (i.e. capelin and herring), shrimp and pollock respond to variations in water temperatures which vary with the climate. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The IPHC longline fishery is identified as a non-contributing factor to prey availability since the bycatch of prey species is not expected in this fishery. The State of Alaska herring fishery is identified as a potential adverse contributor to prey availability by reducing the availability of herring.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the BSAI arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI arrowtooth flounder include climate changes and regime shifts. Persistent past effects of the foreign, JV, and domestic fisheries are described in Section 3.5.1.8.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI arrowtooth flounder stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fishery and the State of Alaska herring fishery are both identified as non-contributing factors to BSAI arrowtooth flounder habitat suitability. The impacts from the fishery gear is expected to be minimal.

- **Cumulative Effects.** A cumulative effect is identified for BSAI arrowtooth flounder habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the arrowtooth flounder stock to sustain itself at or above the MSST is jeopardized.

GOA Arrowtooth Flounder – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total Biomass

The total biomass of GOA arrowtooth flounder at the start of 2002 is estimated to be 1,816,000 mt. Model projections of future total GOA biomass estimates are shown in Table H.4-29 of Appendix H. Under FMP 2.1, model projections indicate that the total GOA biomass is expected to increase 15 percent of the 2002 value to 2,086,000 mt by 2007, with a 2003-2007 average value of 1,982,000 mt. Under FMP 2.2, model projections indicate that the total BSAI biomass is expected to increase about 14 percent of the 2002 value to 2,080,000 mt by 2007, with a 2003-2007 average value of 1,979,000 mt.

Spawning Biomass

Spawning biomass of female GOA arrowtooth flounder at the start of 2002 is estimated to be 1,113,800 mt. Model projections of future arrowtooth flounder spawning biomass estimates are shown in Table H.4-29 of Appendix H. Under FMP 2.1, model projections indicate that female spawning biomass is expected to increase 2 percent of the 2002 value to 1,125,800 mt by 2007, with a 2003-2007 average value of 1,127,200 mt. Projected female spawning biomass is estimated to remain above the B_{MSY} proxy value of 432,700 mt throughout the five year projection.

Under FMP 2.2, model projections indicate that female spawning biomass is expected to increase 3 percent of the 2002 value to 1,151,300 mt by 2007, with a 2003-2007 average value of 1,140,200 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 432,700 mt throughout the five year projection.

Fishing Mortality

The average annual fishing mortality imposed on the GOA arrowtooth flounder stock in 2002 is 0.017. Under FMP 2.1, model projections indicate that fishing mortality will remain at about this level at 0.017 or 0.018 each year through 2007. Under FMP 2.2, model projections show this value will steadily decrease to 0.01 by 2007. These projected values are below the F_{MSY} proxy value (0.165), the rate associated with the OFL (Table H.4-29 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual GOA arrowtooth flounder harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed (Walrus Island, red king crab savings area, etc.) or areas which were previously avoided because of high bycatch.

Because FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that arrowtooth flounder fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual GOA arrowtooth flounder harvest would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

Model projections of future catches of GOA arrowtooth flounder are below the OFLs in 2004-2007 under FMP 2.1 and FMP 2.2. The GOA arrowtooth flounder female spawning biomass is above the MSST level throughout the five year projection and in the 2002 baseline year.

Age and Size Composition

Under FMP 2.1, the mean age of the GOA arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-29 of Appendix H), is 5.0 years. Under FMP 2.2, the mean age of the GOA arrowtooth flounder stock in 2008, as computed in model projections (Table H.4-29 of Appendix H), is 5.0 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.1 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

Fishery-independent resource assessment surveys in the GOA have found that populations of arrowtooth flounder are comprised of a higher percentage of females than males. It is believed that this is a function of a higher natural mortality rate for males than females. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1and FMP 2.2 on GOA arrowtooth flounder would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1.

Summary of Effects of FMP 2.1 and FMP 2.2 – GOA Arrowtooth Flounder

Under FMP 2.1 and FMP 2.2, the spawning stock biomass of GOA arrowtooth flounder is expected to be above the MSST. Since the fishing mortality rate does not exceed F_{OFL} and the female spawning stocks are expected to remain above the MSST, the expected changes under this FMP are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under these FMPs are considered insignificant (Table 4.6-1).

Relative to the 2002 comparative baseline, the GOA spawning biomass is projected to continue to not be overfished under these FMPs. The 20 year projection (Table H.4-29 of Appendix H) indicates that both female spawning stocks are expected to remain above B_{ABC} levels through the end of the projection in 2023.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for GOA arrowtooth flounder are summarized in Table 4.5-14.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA arrowtooth flounder is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the GOA arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for mortality of GOA arrowtooth flounder, and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on GOA arrowtooth flounder biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the GOA arrowtooth flounder stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA arrowtooth flounder, and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects identified for the change in genetic structure and reproductive success of GOA arrowtooth flounder are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success and genetic structure of arrowtooth flounder are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the arrowtooth flounder catch, and is ranked as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the GOA arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified include climate changes and regime shifts (see Section 3.5.1.21).

- **Reasonably Foreseeable Future External Effects.** Future external effects on prey availability are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the GOA arrowtooth flounder is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for the habitat suitability of GOA arrowtooth flounder are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on habitat suitability are the same as those described for BSAI arrowtooth flounder under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for GOA arrowtooth flounder habitat suitability, and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the arrowtooth flounder stock to sustain itself at or above the MSST is jeopardized.

4.6.1.9 Greenland Turbot and Deepwater Flatfish

BSAI Greenland turbot and GOA deepwater flatfish are described in more detail in Sections 3.5.1.9 and 3.5.1.22 of this Programmatic SEIS. Greenland turbot is managed as its own stock under the BSAI groundfish FMP under the Tier 3 management category; thus MSSTs are defined for these species. The reference fishing mortality rate and ABC for the GOA deepwater flatfish management group are determined by the amount

of population information available. ABCs for Dover sole were calculated using Tier 5. Greenland turbot and deepsea sole are in Tier 6 because no reliable biomass estimates exist.

BSAI Greenland Turbot – Direct/Indirect Effects of FMP 2.1

Total Biomass

The total biomass of Greenland turbot at the start of 2002 is estimated to be 106,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-5 of Appendix H. Under FMP 2.1, model projections indicate that the total BSAI biomass is expected to decline 39 percent of the 2002 value to 64,000 mt by 2007, with a 2003-2007 average value of 77,000 mt.

Spawning Biomass

Spawning biomass of female Greenland turbot at the start of 2002 is estimated to be 67,800 mt. Model projections of future Greenland turbot spawning biomass estimates are shown in Table H.4-5 and Figure H.4-4 of Appendix H. Under FMP 2.1, model projections indicate that female spawning biomass is expected to decline 57 percent of the 2002 value to 29,300 mt by 2007, with a 2003-2007 average value of 42,500 mt. Projected female spawning biomass is estimated to decline below the B_{MSY} proxy value of 47,570 mt (after five years of harvest at the F_{MSY} value) by the end of the five year projection.

Fishing Mortality

The average annual fishing mortality imposed on the Greenland turbot stock in 2002 is 0.052. Model projections show this value will increase to 0.483 for each year of the projection through 2007. This level of harvest is at, but does not exceed the F_{MSY} proxy value, the rate associated with the OFL (Table H.4-5 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual BSAI Greenland turbot harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed (Walrus Island, red king crab savings area, etc.), although these locations are shallow areas which are not habitat for adult Greenland Turbot. In addition, they may fish in areas they purposefully avoided in the baseline year due to high bycatch rates.

Status Determination

Model projections of future catches of BSAI Greenland turbot do not exceed the OFL in 2003-2007 under FMP 2.1. However, the female spawning stock is below the MSST level during the five year projection under the FMP 2.1 harvest scenario. The Greenland turbot stock is above the MSST level in the baseline year 2002.

Age and Size Composition

Under FMP 2.1, the mean age of the BSAI Greenland turbot stock in 2008, as computed in model projections (Table H.4-5 of Appendix H), is 4.1 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.9 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model

projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Greenland turbot in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 on Greenland turbot would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1.

Summary of Effects of FMP 2.1 – BSAI Greenland Turbot

Under FMP 2. 1, the spawning stock biomass of BSAI Greenland turbot is expected to be below the MSST. The fishing mortality rate does not exceed $F_{OFL,}$ but the stock is expected to fall below the MSST. Therefore the expected changes under this FMP are substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, there are significantly adverse direct effects on the change in reproductive success, genetic structure and the change in biomass under this FMP. The other direct and indirect effects are considered insignificant (Table 4.6-1).

Relative to the 2002 comparative baseline, the Greenland turbot stock is projected to be overfished under this FMP. The 20 year projection (Figure H.4-4 of Appendix H) indicates that the female spawning stock is expected to decline until 2007 to below B_{MSY} levels and will increase thereafter through the end of the projection but still remain below the B_{MSY} spawning stock level in 2023.

Cumulative Effects of FMP 2.1

Cumulative effects for BSAI Greenland turbot are summarized in Table 4.5-15.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Greenland turbot is rated as insignificant under FMP 2.1 since the projected fishing mortality rates are at the OFL for this stock.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause Greenland turbot mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of Greenland turbot.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Greenland turbot and is rated as insignificant. Fishing mortality at projected levels is at the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on BSAI Greenland turbot biomass is significantly adverse.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause Greenland turbot mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the Greenland turbot biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts see Sections 3.5.1.9 and 3.10.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI Greenland turbot, and is rated as significantly adverse. The female spawning biomass level is projected to fall below the B_{MSY} proxy value. The combined effect of internal removals and removals due to reasonably foreseeable future external events is likely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 the effect of the spatial/temporal concentration of catch is considered significantly adverse for the stock.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the spatial/temporal concentration of BSAI Greenland turbot catch. Climate changes and regime shifts are suspected of having an effect on the reproductive success of the Greenland turbot stock (see Section 3.5.1.9).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of Greenland turbot due to climate changes and regime shifts are potential beneficial or

adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI Greenland turbot.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the Greenland turbot catch and is rated as significantly adverse. The expected changes under FMP 2.1 are substantial enough to expect that the reproductive success and genetic structure of the spawning stocks would be affected. The combined effect of internal removals and removals due to reasonably foreseeable external events is likely to sufficiently alter the genetic structure and the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1, the change in prey availability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects.** Past effects are identified for the change in prey availability of the BSAI Greenland turbot stock. Past foreign, JV, and domestic fisheries have been identified as having influenced the availability of Greenland turbot prey, mainly pollock which is their main prey item in the BSAI. Climate changes and regime shifts have also been identified as influencing Greenland turbot prey availability (see Section 3.5.1.9).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI Greenland turbot stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1, the change in habitat suitability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for BSAI Greenland turbot include climate changes and regime shifts. The foreign, JV, and domestic fisheries have also influenced the habitat suitability of Greenland turbot, largely through the impacts of fishing gear on benthic habitats (see Section 3.5.1.9).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI Greenland turbot stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for BSAI Greenland turbot habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Greenland turbot stock to sustain itself at or above the MSST is jeopardized.

GOA Deepwater Flatfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for these species.

Fishing Mortality

The catch of GOA deepwater flatfish in 2002 was estimated to be 600 mt. Model projections of future catch are shown in Table H.4-25 of Appendix H. Under FMP 2.1, model projections indicate that the catch is expected to increase over four times the 2002 value to 2,400 mt by 2007, with a 2003-2007 average value of 2,600 mt. Under FMP 2.2, model projections indicate that the catch is expected to increase twice the 2002 value to 1,200 mt by 2007, with a 2003-2007 average value of 1,200 mt.

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual GOA deepwater flatfish harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed, or areas they previously avoided due to high bycatch rates.

Since FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that GOA deepwater flatfish fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual this fishery would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

The available information for flatfish species in the deepwater complex requires that they are classified into either the Tier 5 or Tier 6 management category. As a result, no MSSTs are defined for these species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

The sex ratio of deepwater flatfish in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on deepwater flatfish would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1and FMP 2.2 – GOA Deepwater Flatfish

The direct and indirect effects of FMP 2.1 and FMP 2.2 on GOA deepwater flatfish cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of these stocks is over the five year projection and what level of fishing mortality corresponds to the modeled catch estimated under these FMPs (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for GOA deepwater flatfish are summarized in Table 4.5-16.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA deepwater flatfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the GOA deepwater flatfish stock.

- **Reasonably Foreseeable Future External Effects.** Past effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause deepwater flatfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of deepwater flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor since bycatch of deepwater flatfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA deepwater flatfish and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Total and spawning biomass estimates are unavailable for the deepwater flatfish species, therefore, the effects of FMP 2.1 and FMP 2.2 on the change in biomass level are unknown.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the GOA deepwater flatfish stock complex.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause deepwater flatfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the deepwater flatfish species biomass level. For more information on climate changes and regime shifts (see Sections 3.5.1.22 and 3.10). The State of Alaska scallop fishery has been identified as a non-contributing factor for change in biomass level since deepwater flatfish species bycatch is not expected to occur.

- **Cumulative Effects.** Cumulative effects are possible for the change in biomass level of GOA deepwater flatfish, but is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch
  - Change in Genetic Structure of Population
  - Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is unknown for the stock since the MSST is unable to be determined.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts which are suspected of having an effect on the reproductive success of the deepwater flatfish stock complex (see Section 3.5.1.22).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of GOA deepwater flatfish due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA deepwater flatfish. The State of Alaska scallop fishery is identified as a non-contributing factor to change in genetic structure and reproductive success since bycatch of GOA deepwater flatfish species is not expected to occur.

- **Cumulative Effects.** Cumulative effects are possible for the spatial/temporal concentration of the GOA deepwater flatfish catch; however, this effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain current population levels is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the GOA deepwater flatfish complex is unknown.

- **Persistent Past Effects.** Paste effects are identified for the change in prey availability of the GOA deepwater flatfish stock complex and include climate changes and regime shifts (see Section 3.5.1.22).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA deepwater flatfish stock complex are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST. The State of Alaska scallop fishery has been identified as a potential adverse contributor to benthic prey availability (see Section 3.6).

- **Cumulative Effects.** A cumulative effects is identified for change in prey availability; however, this effect is unknown. It is unknown whether the combination of internal and external removals of prey is expected to jeopardize the ability of the stock to maintain current populations.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the GOA deepwater flatfish complex is unknown.

- **Persistent Past Effects.** Past effects identified for GOA deepwater flatfish include climate changes and regime shifts. The foreign, JV, and domestic fisheries have also influenced the habitat suitability of deepwater flatfish, largely through the impacts of fishing gear on benthic habitats (see Section 3.5.1.22).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA deepwater flatfish stock complex are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery has been identified as a potential adverse contributor to habitat suitability (see Section 3.6).

- **Cumulative Effects.** A cumulative effect is identified for GOA deepwater flatfish habitat suitability; however, this effect is unknown. It is unknown whether the combination of internal and external habitat disturbances is expected to lead to a detectable change in spawning or rearing success such that the ability of the deepwater flatfish stock complex to maintain current population levels is jeopardized.

BSAI Greenland Turbot – Direct/Indirect Effects of FMP 2.2

Total Biomass

The total biomass of Greenland turbot at the start of 2002 is estimated to be 106,000 mt. Model projections of future total BSAI biomass estimates are shown in Table H.4-5 of Appendix H. Under FMP 2.2, model projections indicate that the total BSAI biomass is expected to decline about 19 percent of the 2002 value to 86,000 mt by 2007, with a 2003-2007 average value of 91,000 mt.

Spawning Biomass

Spawning biomass of female Greenland turbot at the start of 2002 is estimated to be 67,800 mt. Model projections of future Greenland turbot spawning biomass estimates are shown in Table H.4-5 of Appendix H. Under FMP 2.2, model projections indicate that female spawning biomass is expected to decline 31 percent of the 2002 value to 46,600 mt by 2007, with a 2003-2007 average value of 53,800 mt. Projected female spawning biomass is estimated to be above the B_{MSY} proxy value of 47,570 mt for 2003-2006 and then drop 930 mt below the B_{MSY} proxy value in 2007.

Fishing Mortality

The average annual fishing mortality imposed on the Greenland turbot stock in 2002 is 0.052. Model projections show this value will increase to 0.19 in 2003 and 2004 and then decrease to 0.16 in 2007. This maximum value under this FMP is less than the F_{MSY} proxy value of 0.48, the rate associated with the OFL (Table H.4-5 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

Since this FMP allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that Greenland turbot fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual BSAI Greenland turbot harvest would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

Model projections of future catches of BSAI Greenland turbot are below the OFLs in all years under FMP 2.2. The Greenland turbot female spawning stock is above the MSST level under this FMP, as in the baseline year 2002.

Age and Size Composition

Under FMP 2.2, the mean age of the BSAI Greenland turbot stock in 2008, as computed in model projections (Table H.4-5 of Appendix H), is 4.6 years. This compares with a mean age in the equilibrium unfished BSAI stock of 5.9 years. Note that the mean ages and sizes actually observed in 2008 (as opposed to the model projections of mean age in 2008) will be driven largely by the strengths of incoming recruitments during the intervening years.

Sex Ratio

The sex ratio of Greenland turbot in the BSAI is assumed to be 50:50.No information is available to suggest that this would change under FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.2 on Greenland turbot would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.2.

Summary of Effects of FMP 2.2 – BSAI Greenland Turbot

Under FMP 2.2, the spawning stock biomass of BSAI Greenland turbot is expected to be above the MSST. Since the fishing mortality rate does not exceed F_{OFL} and the female spawning stock is expected to remain above the MSST, the expected changes under this FMP are not substantial enough to expect that the genetic diversity or the reproductive success of the spawning stocks would change under the new management regime. Thus, the indirect and direct effects under this FMP are considered insignificant (Table 4.6-1).

Relative to the 2002 comparative baseline, the Greenland turbot stock is projected to continue to not be overfished under this Alternative. The 20 year projection (Figure H.4-4 of Appendix H) indicates that the female spawning stock is expected to decline until 2007 to B_{MSY} levels and will increase thereafter through the end of the projection to above B_{ABC} spawning stock levels in 2023.

Cumulative Effects of FMP 2.2

Cumulative effects for BSAI Greenland turbot are summarized in Table 4.5-15.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Greenland turbot is rated as insignificant under FMP 2.2.

- **Persistent Past Effects.** Past effects have not been identified for fishing mortality in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** External effects on mortality are the same as those described under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Greenland turbot and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** As stated in the direct/indirect effects section, the effect of the fisheries on BSAI Greenland turbot biomass is insignificant.

- **Persistent Past Effects.** Past effects have not been identified for the change in biomass in the BSAI Greenland turbot stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass level are the same as those described under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of BSAI Greenland turbot and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock and the female spawning biomass is above the B_{MSY} value from 2003-2006. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.2 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects identified for the spatial/temporal concentration of BSAI Greenland turbot are the same as those described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success and genetic structure of Greenland turbot are the same as those described under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the Greenland turbot catch and is rated as insignificant. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.2, the change in prey availability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for the change in prey availability of the BSAI Greenland turbot are the same as those described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability are the same as those described under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.2, the change in habitat suitability for the BSAI Greenland turbot is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for the habitat suitability of BSAI Greenland turbot are the same as those described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on habitat suitability are the same as those described under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for BSAI Greenland turbot habitat suitability and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Greenland turbot stock to sustain itself at or above the MSST is jeopardized.

4.6.1.10 Alaska Plaice and Other Flatfish and Rex Sole

BSAI Alaska plaice and other flatfish and GOA rex sole fisheries are described in more detail in Sections 3.5.1.10 and 3.5.1.23 of this Programmatic SEIS.

BSAI Alaska Plaice – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total Biomass

Total biomass of BSAI Alaska plaice at the start of 2003 is estimated to be 1,083,000 mt. Model projections of future total Alaska plaice BSAI biomass are shown in Table H.4-9 of Appendix H. Under FMP 2.1, model projections indicate that BSAI biomass is expected to increase to a value of 1,098,000 mt in 2007, with a 2003-2007 average value of 1,089,000 mt. Under FMP 2.2, model projections indicate that BSAI Alaska plaice biomass is expected to increase to a value of 1,112,000 mt in 2008, with a 2003-2008 average value of 1,097,000 mt.

Spawning Biomass

Spawning biomass of BSAI Alaska plaice at the start of 2003 is estimated to be 274,800 mt. Model projections of future total BSAI biomasses are shown in Table H.4-9 and Figure H.4-8 of Appendix H. Under FMP 2.1, model projections indicate that BSAI Alaska plaice biomass is expected to decrease to a value of

270,700 mt in 2005, and then increase to 273,200 mt in 2007. The projected average biomass from 2003-2007 is 272,400 mt. Under FMP 2.2, model projections indicate that BSAI Alaska plaice biomass is expected to decrease to a value of 273,200 mt in 2005 and increase to 279,300 mt in 2008, with a 2003-2008 average value of 275,400 mt.

Fishing Mortality

Under FMP 2.1, the projected fishing mortality imposed on the BSAI Alaska plaice stock is 0.032 in 2003, and decreases to 0.026 in 2007. The proportion of spawner biomass per recruit conserved under these fishing mortality rates is 86 percent in 2003 and increases to 88 percent in 2007, with an average of 87 percent from 2003-2007 (Table H.4-9 of Appendix H).

Under FMP 2.2, the projected fishing mortality imposed on the BSAI Alaska plaice stock is approximately 0.027 in 2003, decreasing to 0.021 in 2008. The proportion of spawner biomass per recruit conserved under these fishing mortality rates is 88 percent in 2003 and increases to 90 percent in 2008, with an average of 89 percent from 2003-2008 (Table H.4-9 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 2.1 involves the resumption of fishing in a number of areas currently closed, and these areas are largely in the EBS. Although most of the bycatch of Alaska plaice still occurs in the yellowfin sole fishery, a greater proportion is taken in the Pacific cod trawl fishery. An average of 17,800 mt was projected to be annually harvested from 2003-2008, with 10,710 mt (60 percent) from the yellowfin sole fishery and 4,040 mt (22 percent) from the Pacific cod trawl fishery.

Under FMP 2.2, the average projected catch from 2003-2008 is 13,000 mt, of which 9,500 mt (73 percent) occurred in the EBS shelf yellowfin sole fishery and 1,900 mt (14 percent) occurred in the EBS shelf rock sole fishery.

Status Determination

Under FMP 2.1, the ABC is set equal to the OFL, removing the buffer between these two harvest regulations. Model projections of future catches of BSAI Alaska plaice are below the OFL level from 2003 to 2008.

Under FMP 2.2, the ABC is set lower than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI Alaska plaice are below ABC and OFL levels from 2003 to 2008.

Age and Size Composition

Under FMP 2.1, the mean age of the BSAI Alaska plaice stock in 2008, as computed in model projections, is 4.36 years. Under FMP 2.2, the mean age of the BSAI Alaska plaice stock in 2008, as computed in model projections (Table H.4-9 of Appendix H), is 4.38 years. This compares with a mean age in the equilibrium unfished stock of 4.51 years.

Sex Ratio

The sex ratio of BSAI Alaska plaice is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 and FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under this FMP 2.1 and FMP 2.2.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – BSAI Alaska Plaice

Although the ABC and OFL levels for Alaska plaice are equivalent under FMP 2.1, and the F_{OFL} is not reduced for lower stock sizes, the harvest of Alaska plaice under FMP 2.1 is reduced so the direct and indirect effects are considered insignificant. Fishing rates are at the $F_{85\%}$ level, which are lower than accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment.

Because the BSAI Alaska plaice are fished at less than the ABC and are above the minimum stock size threshold, the direct and indirect effects under FMP 2.2 are considered insignificant. Fishing rates are lower than accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity (Table 4.6-1).

Relative to the 2002 comparative baseline, the Alaska plaice stock is projected to continue to not be overfished under this FMP. The twenty year projection (Figure H.4-8 of Appendix H) indicates that the female spawning stock is expected to remain at a high and stable level well above B_{ABC}.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for BSAI Alaska plaice are summarized in Table 4.5-17.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Alaska plaice stock is insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** No lingering past effects on BSAI Alaska plaice have been identified.

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor to mortality of BSAI Alaska plaice. Acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as contributors to mortality since a change is not expected to be significant in magnitude to cause mortality.

- **Cumulative Effects.** Under FMP 2.1 and FMP 2.2, a cumulative effect is identified for BSAI Alaska plaice mortality; however, that effect is considered insignificant. Alaska plaice are fished above the ABC and OFL values. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Alaska plaice stock is expected to be insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** No lingering past effects on BSAI Alaska plaice have been identified.

- **Reasonably Foreseeable Future External Effects.** Marine pollution events are identified as potential adverse contributors to BSAI Alaska plaice change in biomass level. Acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the stock is unable to maintain MSST. Climate changes and regime shifts are identified as potential beneficial or adverse contributors to change in biomass level, since recruitment is affected by climate changes and regime shifts through a combination of prey availability and habitat suitability effects.

- **Cumulative Effects.** A cumulative effect is identified for BSAI Alaska plaice change in biomass; however, it is determined to be insignificant. The combination of internal and external factors are not expected to reduce Alaska plaice biomass such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 are determined to have an insignificant effect on BSAI Alaska plaice spatial/temporal characteristics.

- **Persistent Past Effects.** No persistent past effects have been identified for the genetic structure of the BSAI Alaska plaice population. Although, climate changes and regime shifts have been identified as having a potential beneficial or adverse effect on BSAI Alaska plaice reproductive success.

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contribution to BSAI Alaska plaice genetic structure and reproductive success. Acute and/or chronic events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and could also result in reduced recruitment. Climate

changes and regime shifts have been identified as potential beneficial or adverse contributor to the reproductive success of BSAI Alaska plaice, but as a non-contributing factor to the genetic structure of Alaska plaice. The reproductive success is affected through a combination of climate induced changes in prey availability and habitat suitability.

- **Cumulative Effects.** A cumulative effect has been identified for the spatial/temporal concentration of BSAI Alaska plaice; however, it is determined to be insignificant. The combined internal and external events are not expected to significantly alter the reproductive success or genetic structure such that it jeopardizes the capacity of the stock to maintain itself above MSST.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 is determined to have an insignificant effect on BSAI Alaska plaice prey availability.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having potential adverse or beneficial effects on BSAI Alaska plaice prey availability. Little research has been conducted on benthic invertebrates, the main prey species of Alaska plaice, therefore the magnitude and direction of the effects imposed by climate changes and regime shifts are unknown.

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor to the prey availability of BSAI Alaska plaice. Acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above the MSST. Climate changes and regime shifts are identified as potential beneficial or adverse contributors to BSAI Alaska plaice prey availability. However, as stated above, since little research has been conducted on the effects of climate changes on benthic invertebrates, the magnitude and direction of the changes are unknown.

- **Cumulative Effects.** A cumulative effect has been identified for the BSAI Alaska plaice change in prey availability; however, the effect is identified as insignificant. The combination of internal and external removals of prey species is not expected to decrease prey availability such that the BSAI Alaska plaice stock is unable to maintain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 is determined to have an insignificant effect on Alaska plaice habitat suitability.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries have been identified as having adverse effects on BSAI Alaska plaice habitat. See Sections 3.5.1.10 and 3.6 for more information on the effects of fishing gear on flatfish habitat. Climate changes and regime shifts are also identified as having a potential adverse or beneficial effect on Alaska plaice habitat (see Sections 3.5.1.10 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to BSAI Alaska plaice habitat suitability. Acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success of Alaska

plaice. Climate changes and regime shifts have also been identified as having potential beneficial or adverse contributions to BSAI Alaska plaice habitat suitability. In general, when the Aleutian Low is strong and corresponding water temperatures are high, flatfish recruitment is favored.

- **Cumulative Effects.** A cumulative effect for BSAI Alaska plaice change in habitat suitability is identified and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the BSAI Alaska plaice stock to maintain itself at or above the MSST is jeopardized.

BSAI Other Flatfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total and Spawning Biomass

Total and spawning biomass estimates are not available for these species.

Fishing Mortality

The catch of BSAI other flatfish in 2002 was estimated to be 2,600 mt. Model projections of future catch are shown in Table H.4-10 of Appendix H. Under FMP 2.1, model projections indicate that the 2003 catch is expected to increase from the 2002 value to 3,300 mt in 2003 and then gradually decrease each year to 2,800 mt in 2007 (7 percent increase from 2002). The 2003-2007 average catch is 3,000 mt. Under FMP 2.2, model projections indicate that the catch is expected to increase 18 percent from the 2002 value to 3,100 mt in 2003 and then decrease to 2,800 mt in 2007 (3 percent increase from 2002). The 2003-2007 average catch is 2,700 mt.

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual BSAI Other flatfish harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed (Walrus Island, red king crab savings area, etc.) or areas they previously avoided due to high bycatch rates.

Since FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that Other flatfish fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of their harvest would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

The available information for flatfish species in the deepwater complex requires that they are classified into either the Tier 4 or Tier 5 management category. As a result, no MSSTs are defined for these species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are not available for these species.

Sex Ratio

The sex ratios the species of the Other flatfish category in the BSAI is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on other flatfish would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1of FMP 2.2 – BSAI Other Flatfish

The available information for flatfish species in the deepwater complex requires that they are classified into either the Tier 4 or Tier 5 management category. As a result, no MSSTs are defined for these species. Therefore, it is not possible to determine their status (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for BSAI other flatfish are summarized in Table 4.5-18.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI other flatfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects have not been identified for BSAI other flatfish mortality.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI other flatfish and is rated as insignificant. Fishing mortality rates for projected years are well below the other flatfish OFL. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of changes in biomass level is rated as unknown since the MSST for this stock is not possible to be determined.

- **Persistent Past Effects.** Past effects have not been identified for the BSAI other flatfish change in biomass level effect indicator.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass level are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI other flatfish, but the effect is unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for the spatial/temporal concentration of catch are the same as those described for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the spatial/temporal characteristics of the BSAI other flatfish stock are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the other flatfish catch; however, these effects are unknown since the MSST is not possible to be determined. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the BSAI other flatfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for the change in prey availability are the same as those described for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects identified for the change in prey availability are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability; however, this effect is unknown since it is not possible to determine the MSST. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the BSAI other flatfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for habitat suitability of BSAI other flatfish are the same as those described for BSAI Alaska plaice under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects identified for habitat suitability of BSAI other flatfish are the same as those described for BSAI Alaska plaice under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for BSAI other flatfish habitat suitability; however, this effect is unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

GOA Rex Sole – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total and Spawning Biomass

Total and spawning biomass estimates are not available for this species.

Fishing Mortality

The catch of GOA rex sole in 2002 was estimated to be 3,000 mt. Model projections of future catch are shown in Table H.4-26 of Appendix H. Under FMP 2.1, model projections indicate that the catch is expected to increase to 9,300 mt in 2003 and remain at 9,200 for 2004-2007. The 2003-2007 average catch is 9,300 mt. Under FMP 2.2, model projections indicate that the catch is expected to increase to 3,400 mt in 2004 and then decrease to 3,200 mt by 2007. The 2003-2007 average catch is 3,300 mt.

Spatial/Temporal Concentration of Fishing Mortality

The spatial/temporal characteristics of the annual GOA rex sole harvest could be affected under FMP 2.1 if harvesters chose to fish in the areas which were formerly closed, or areas they previously avoided due to high bycatch rates.

Since FMP 2.2 allows for setting PSC limits proportional to the abundance of the bycatch species, it is possible that GOA rex sole fishermen would spend less effort in bycatch avoidance in years where bycatch species were abundant. Otherwise, the spatial/temporal characteristics of the annual GOA rex sole harvest would not be affected under FMP 2.2 relative to the baseline year 2002.

Status Determination

The available information for GOA rex sole requires that they are classified into the Tier 5 management category. As a result, no MSSTs are defined for this species. Therefore, it is not possible to determine their status.

Age and Size Composition

Age and size composition estimates are not available for this species.

Sex Ratio

The sex ratio of rex sole in the GOA is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under these FMPs.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 on rex sole would be governed by a complex web of indirect interactions that are currently difficult to quantify. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 and FMP 2.2.

Summary of Effects of FMP 2.1and FMP 2.2 – GOA Rex Sole

Except for the effects of mortality, the direct and indirect effects of FMP 2.1 and FMP 2.2 on GOA rex sole cannot be determined from the MSST criteria used for stocks in Management Category Tiers 1-3. It is unknown what the estimate of female spawning biomass of this stock is over the five year projection and what level of fishing mortality corresponds to the modeled catch estimated under these FMPs. The projected catch for both FMPs are under the OFL for all projected years, therefore FMP 2.1 and FMP 2.2 is expected to have insignificant effects of GOA rex sole through mortality (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for rex sole are summarized in Table 4.5-19.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA rex sole is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Large removals of rex sole by the past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA rex sole stocks. See Section 3.5.1.23 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rex sole mortality. Climate changes and regime shifts are considered

non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of rex sole. The State of Alaska scallop fishery has also been identified as a non-contributing factor since it is not expected to contribute to direct mortality of rex sole.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA rex sole and is rated as insignificant. Fishing mortality rates for projected years are well below the rex sole OFL. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of changes in biomass level is rated as unknown since the MSST for this stock is not possible to be determined.

- **Persistent Past Effects.** Large removals of rex sole by past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA rex sole stocks see Section 3.5.1.23 for details regarding these effects.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause rex sole mortality. Climate changes and regime shifts have also been identified as having an indirect potential beneficial or adverse effect on the rex sole biomass level. When the Aleutian Low is strong and water temperatures warm, flatfish recruitment is favored, likewise when the Aleutian Low is weak and the temperatures cooler, recruitment tends to be weak. The State of Alaska Scallop Fishery is identified as a non-contributing factor since it is not expected to contribute to direct mortality of rex sole. For more information on climate changes and regime shifts see Sections 3.5.1.23 and 3.10.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA rex sole, but is rated as unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects are not identified for genetic structure of the population; however, climate changes and regime shifts are identified as having persistent past effects on the reproductive success of the GOA rex sole stock. See Sections 3.5.1.23 and 3.10 for more information of climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the genetic structure of rex sole include the potential adverse effects of marine pollution since an acute and/or chronic pollution event could alter the genetic structure of the population by causing localized mortality. The State of Alaska scallop fishery and climate changes and regime shifts have both been identified as non-contributing factors to the change in genetic structure of rex sole stocks. These events are not expected to cause localized depletions that would alter the genetic sub-population structure of rex sole stock. Change in reproductive success of rex sole due to climate changes and regime shifts are identified as having a potential beneficial or adverse effect. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could also the reproductive success of GOA rex sole. Again, the State of Alaska scallop fishery has been identified as a non-contributing factor since the scallop fishery is not expected to contribute to rex sole removals.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the rex sole catch; however, this effect is unknown since the MSST is not possible to be determined. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the GOA rex sole is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Climate changes and regime shifts are identified as having had effected the prey availability of the GOA rex sole stock. The actual effect of climate changes and regime shifts on rex sole prey availability is unknown, but could have had a potential beneficial or adverse effect. See Sections 3.5.1.23 and 3.10 for more information on climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Past effects of the climate changes and regime shifts on the GOA rex sole stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The State of Alaska scallop fishery has been identified as having a potential adverse effect on rex sole prey availability since the habitat disturbances caused by dredging could influence the availability of benthic prey.

- **Cumulative Effects.** A cumulative effect is possible for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the GOA rex sole is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for GOA rex sole include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown,

but could have a potential beneficial or adverse effect. Habitat disturbances caused by the past foreign, JV, and domestic fisheries have also been identified as having persistent past effects on the GOA rex sole stock see Sections 3.5.1.23 and 3.10 for more information regarding the past fisheries and climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA rex sole stock are potential beneficial or adverse. When the Aleutian Low is strong and water temperatures warm, flatfish recruitment is favored, likewise when the Aleutian Low is weak and water temperatures cooler, flatfish recruitment is reduced. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The State of Alaska scallop fishery is identified as having potential adverse effects on rex sole habitat suitability that may cause changes in the spawning or rearing success of the stock.

- **Cumulative Effects.** A cumulative effect is possible for GOA rex sole habitat suitability; however, this effect is unknown. The combined effect of internal removals and removals due to reasonably foreseeable future external events may or may not jeopardize the capacity of the stock to maintain current population levels.

4.6.1.11 Pacific Ocean Perch

Pacific ocean perch (*Sebastes alutus*) are managed under Tier 3 in both the BSAI and GOA. Sections 3.5.1.11 and 3.5.1.24 discuss the past/present analysis in further detail.

BSAI Pacific Ocean Perch – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total Biomass

Total biomass of BSAI Pacific ocean perch at the start of 2003 is estimated to be 374,000 mt. Model projections of future total BSAI Pacific ocean perch biomass are shown in Table H.4-12 of Appendix H. Under FMP 2.1, model projections indicate that BSAI Pacific ocean perch biomass is expected to decrease to a value of 360,000 mt in 2008, with a 2003-2008 average value of 366,000 mt. Under FMP 2.2, model projections indicate that BSAI Pacific ocean perch biomass is expected to increase to a value of 383,000 mt in 2008, with a 2003-2008 average value of 379,000 mt.

Spawning Biomass

Spawning biomass of BSAI Pacific ocean perch at the start of 2003 is estimated to be 134,700 mt. Model projections of future total BSAI Pacific ocean perch biomass are shown in Table H.4-12 and Figure H.4-10 of Appendix H. Under FMP 2.1, model projections indicate that BSAI Pacific ocean perch biomass is expected to decrease to a value of 122,400 mt in 2008, with a 2003-2008 average value of 127,700 mt. Under FMP 2.2, model projections indicate that BSAI Pacific ocean perch biomass is expected to decrease to a value of 133,100 mt in 2005 and remain at this level through 2008, with a 2003-2008 average value of 133,600 mt.

Fishing Mortality

Under FMP 2.1, the projected fishing mortality imposed on the BSAI Pacific ocean perch stock in each year from 2003 to 2008 is 0.057, which is equivalent to the $F_{35\%}$ proxy for the overfishing rate. At this fishing mortality rate, 35 percent of the spawner biomass per recruit would be conserved (Table H.4-12 of Appendix H).

Under FMP 2.2, the projected fishing mortality imposed on the BSAI Pacific ocean perch stock is approximately 0.040 from 2003 to 2006, increasing to 0.042 in 2007 and 2008. The proportion of spawner per recruit biomass conserved under these fishing mortality rates is 45 percent in 2003, increasing to 46 percent in 2005, and decreasing to 44 percent in 2008, with an average of 45 percent from 2003-2008 (Table H.4-12 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

Although FMP 2.1 involves the resumption of fishing in a number of areas currently closed, these areas are largely in the EBS. Over the projection years 2003 to 2008 an average of 800 mt (of 17,700 mt total BSAI Pacific ocean perch catch) are taken annually as bycatch in Bering Sea fisheries, and an average of 11,900 mt are taken by the central Aleutian Islands Pacific ocean perch fishery.

Under FMP 2.2, the proportion of catch occurring in the eastern Aleutian Islands is increased relative to baseline conditions. The average projected catch from 2003-2008 is 13,100 mt, of which 7,700 mt (59 percent) occurred in the eastern Aleutian Islands. This catch is taken largely from directed Pacific ocean perch fisheries, although the Atka mackerel fishery is projected to harvest an average of 200 mt of Pacific ocean perch in each year from 2003 to 2008.

Status Determination

Under FMP 2.1, the ABC is set equal to the OFL, removing the buffer between these two harvest regulations. Under FMP 2.2, the ABC is set lower than the OFL, creating a buffer between these two harvest regulations. Model projections of future catches of BSAI Pacific ocean perch are at the OFL level from 2003 to 2008, and projected spawning stock biomass is above B_{MSY} ($B_{35\%}$) level of 120,200 mt. Thus, BSAI Pacific ocean perch are determined to be above the MSST level for the projection years of 2003-2008 for both FMPs.

Age and Size Composition

Under FMP 2.1, the mean age of the BSAI Pacific ocean perch stock in 2008, as computed in model projections, is 9.93 years. Under FMP 2.2, the mean age of the BSAI Pacific ocean perch stock in 2008, as computed in model projections (Table H.4-12 of Appendix H), is 10.23 years. This compares with a mean age in the equilibrium unfished stock of 14.01 years.

Sex Ratio

The sex ratio of BSAI Pacific ocean perch is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 2.1 or FMP 2.2. However, because BSAI Pacific ocean perch are determined to be above the MSST for the projection years, at they are fished at or above the OFL under these FMPs, FMP 2.1 and FMP 2.2 are determined to have an insignificant effect through habitat suitability.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, because Pacific ocean perch feed mainly on euphausiid species, which are not caught within the groundfish fisheries, the direct and indirect effects of FMP 2.1 and FMP 2.2 are expected to be insignificant through prey availability.

Summary of Effects of FMP 2.1and FMP 2.2 – BSAI Pacific Ocean Perch

Under FMP 2.1, BSAI Pacific ocean perch are fished at rates equal to F_{OFL}, or $F_{35\%}$,, which is somewhat higher than accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. However, the spawning biomass remains above the $B_{35\%}$ level, which is taken as a proxy for Bmsy. Thus, the direct and indirect effects under FMP 2.1 are considered insignificant. The removal of closed areas to fishing in the Bering Sea has little effect on the spatial distribution of the catch in this area, as little Pacific ocean perch are taken in Bering Sea fisheries. However, a fairly large proportion, 67 percent, of the Pacific ocean perch are harvested in the cental Aleutian Islands.

Because the BSAI Pacific ocean perch are fished at less than the ABC and are above the minimum stock size threshold, the direct and indirect effects under FMP 2.2 are considered insignificant. Fishing rates are within accepted scientific standards based on studies of population dynamics and estimates of natural variation of recruitment. Under these considerations, the spatial/temporal distribution of catch should have no significant direct impact on stock productivity (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for BSAI Pacific ocean perch are summarized in Table 4.5-20.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI Pacific ocean perch stock is insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries are identified as having had adverse effects on the BSAI Pacific ocean perch stock. Large removals of Pacific ocean perch occurred in the past and there appears to be a lingering effect on the BSAI populations (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute to BSAI Pacific ocean perch mortality since bycatch in this fishery is not expected. Marine pollution is identified as making a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to Pacific ocean perch mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI Pacific ocean perch and is rated as insignificant. Pacific ocean perch are fished at levels equal to the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the BSAI Pacific ocean perch stock is expected to be insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** The past foreign, JV, and domestic fisheries are identified as having had adverse effects on the BSAI Pacific ocean perch stock. Large removals of Pacific ocean perch occurred in the past and there appears to be a lingering effect on the BSAI populations (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is not expected to contribute significantly to BSAI Pacific ocean perch mortality since bycatch is not expected in this fishery. Therefore, the IPHC longline fishery is also not expected to cause significant changes in biomass levels. Marine pollution is identified as making a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as making beneficial or adverse contributions to Pacific ocean perch change in biomass levels as a function of reproductive success.

- **Cumulative Effects.** A cumulative effect for the change in biomass is identified as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the Pacific ocean perch biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the BSAI Pacific ocean perch population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure. However, there are lingering past effects due to climate changes and regime shifts (see Section 3.5.1.11) for change in reproductive success.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery are not expected to contribute to changes in genetic structure or reproductive success of BSAI Pacific ocean perch since bycatch of BSAI Pacific ocean perch is not expected to occur. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as potential beneficial or adverse contributor to reproductive success since changes in climate can effect prey availability and/or habitat suitability which in turn can effect recruitment. Generally, changes in climate changes that lead to increased advection of the Alaska current are believed to increase euphausiid production, a major prey item of BSAI Pacific ocean perch. Climate changes and regime shifts are not considered to contribute to changes in genetic structure.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 would have insignificant effects on Pacific ocean perch prey availability.

- **Persistent Past Effects.** Past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on Pacific ocean perch prey species (see Section 3.5.1.11).

- **Reasonably Foreseeable Future External Effects.** Future external effects of climate changes and regime shifts on Pacific ocean perch prey species are identified as potential beneficial or adverse contributors. In general, it is believed that climate changes and regime shifts that lead to the increased advection of the Alaska current also increase production of euphausiids, a major prey item of BSAI Pacific ocean perch. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific ocean perch stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 would have an insignificant effect on Pacific ocean perch habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for BSAI Pacific ocean perch stocks include past foreign, JV, and domestic fisheries, IPHC longline fisheries and climate changes and regime shifts (see Section 3.5.1.11). Intense bottom trawling on Pacific ocean perch habitat in the past fisheries likely disrupted spawning and/or rearing habitats in areas of the BSAI. It is possible that some of these areas have not recovered from the intense efforts. The IPHC longline fisheries are

also identified as having adverse effects on Pacific ocean perch habitat, although these fishing gear impacts are considered to be less significant than those associated with trawl gear (see Section 3.6). Climate changes and regime shifts have had both beneficial and adverse effects on Pacific ocean perch habitat.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery is identified as making adverse contributions to Pacific ocean perch habitat through fishing gear impacts. As stated above, these impacts are expected to be of lesser magnitude than those effects associated with trawl gear. Impacts on habitat from climate changes and regime shifts on the BSAI Pacific ocean perch stock are identified as potential beneficial or adverse contributors, although the magnitude and direction of the change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Pacific ocean perch stock to sustain itself at or above MSST is jeopardized.

GOA Pacific Ocean Perch – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total and Spawning Biomass and Fishing Mortality

FMP 2.1 represents a less precautionary approach of fishery management. An important measure in this bookend that would impact all target species is that ABC would be set equal to overfishing. This would eliminate the buffer between ABC and overfishing that exists in FMP 1. Also under FMP 2.1 the eastern GOA trawl closure in FMP 1 would be repealed. Both of these measures in combination would likely result in a larger catch of GOA Pacific ocean perch than has been the case in years past, and increase the risk of overfishing GOA Pacific ocean perch stocks. The bycatch model results for this bookend show increased catches for GOA Pacific ocean perch and therefore appear to be reasonable. Average fishing mortality during the years 2003 - 2008 is expected to be equal to F_{OFL} (0.060) (Table H.4-36 and Figure H.4-15 of Appendix H).

FMP 2.2 is much less aggressive in its approach than FMP 2.1. The two particular measures that impacted GOA Pacific ocean perch catch in FMP 2.1 are not part of FMP 2.2, so catch of GOA Pacific ocean perch in FMP 2.2 should be reduced relative to FMP 2.1 and result in catches similar to those of FMP 1. Bycatch model results for FMP 2.2 show catches comparable to FMP 1 for GOA Pacific ocean perch and therefore appear reasonable. Average fishing mortality during the years 2003 - 2008 is expected to be less than F_{OFL} (0.060).

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.1 the eastern GOA trawl closure in FMP 1 would be repealed. Under FMP 2.1, trawl fishing is permitted in the southeast/east Yakutat area and the ABC (12 percent of the total GOA ABC) normally allocated to that area would now likely to be caught.

The effect of FMP 2.1 on the spatial/temporal concentration of Pacific ocean perch catch is similar to what the baseline situation has been in past years. A major difference of FMP 2.1 versus the baseline for Pacific ocean perch would be the inclusion of the eastern GOA as an open trawl zone. ABC is apportioned by area and inclusion of the eastern GOA would spread effort out resulting in more protection against localized depletion. Fishing effort would continue to be compressed into a relatively short open season especially if high concentrations of Pacific ocean perch are harvested in the eastern GOA. This may result in increasing the risk of possible overfishing because of the difficulty of managing a short, compressed fishery.

FMP 2.2 would have similar effects on the spatial and temporal concentration of Pacific ocean perch catch as the baseline fishing. The inclusion of the eastern Gulf no-trawl zone is consistent with the baseline situation. ABCs are geographically apportioned among management areas which provides some protection against localized depletion. The Pacific ocean perch fishery would likely be concentrated into a relatively short open season, thereby increasing the risk of possible overfishing because of the difficulty of managing a short compressed fishery.

Status Determination

Under FMP 2.1, the projected B2003 of 111,900 mt is greater than $B_{35\%}$ and consequently the stock is projected to be above its MSST and not projected to be in an overfished condition. The projected B2005 of 106,400 mt is greater than $B_{35\%}$ and consequently the stock is not projected to be approaching an overfished condition.

Under FMP 2.2, the projected B2003 of 112,800 mt is greater than $B_{35\%}$ and consequently the stock is projected to be above its MSST and not projected to be in an overfished condition. The projected B_{2005} of 112,800 mt is greater than $B_{35\%}$ and consequently the stock is not projected to be approaching an overfished condition.

Age and Size Composition

Under FMP 2.1 and FMP 2.2, the age composition of GOA Pacific ocean perch may be affected by fishing mortality as in FMP 1. No information is available to suggest that sex ratio would change under these FMPs, but the size composition of GOA Pacific ocean perch might change in proportion to the change in age composition.

Sex Ratio

No information is available to suggest that the sex ratio would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Under FMP 2.1 increased damage to epifauna by increased bottom trawl effort, and the opening of the eastern GOA to bottom trawling may adversely impact the habitat of juvenile Pacific ocean perch. FMP 2.1 also adversely impacts GOA Pacific ocean perch because by opening the eastern GOA to trawling it removes a *de facto* no take zone or refugium for Pacific ocean perch in this area which could reduce the reproductive potential of the stock. However, these impacts on habitat suitability are predicted to be insignificant because the GOA Pacific ocean perch stock is determined to remain above the MSST for all projection years.

Under FMP 2.2 damage to epifauna by bottom trawls may adversely impact juvenile Pacific ocean perch habitat. However, FMP 2.2 may reduce the impacts on habitat for GOA Pacific ocean perch by maintaining the eastern GOA closure to trawling. This provides a *de facto* no take zone or refugium for Pacific ocean perch in this area and provides protection from the potential effects of trawling on adult and juvenile rockfish habitat.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, because Pacific ocean perch feed mainly on euphausiid species, which are not caught within the groundfish fisheries, the direct and indirect effects of FMP 2.1 and FMP 2.2 are expected to be insignificant through prey availability.

Summary of Effects of FMP 2.1 and FMP 2.2 – GOA Pacific Ocean Perch

Under FMP 2.1 and FMP 2.2, average fishing mortality during the years 2003 - 2008 is expected to be less than or equal to F_{OFL}. Consequently fishing mortality is believed to have an insignificant impact on stock sustainability. Under FMP 2.1 and FMP 2.2, the stock is projected to sustain itself at or above MSST. Consequently change in biomass is believed to have an insignificant impact on stock sustainability. Additionally, because the stock is projected to sustain itself at or above MSST, the direct effects of spatial/temporal concentration of catch on change in genetic integrity and reproductive success, as well as the indirect effects of both the change in prey availability and the change in habitat suitability are believed to have an insignificant impact on stock sustainability. For further detail on the past/present effects analysis for GOA Pacific ocean perch, see Section 3.5.1.24 (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for GOA Pacific ocean perch are summarized in Table 4.5-21.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA Pacific ocean perch stock is insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects on mortality are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA Pacific ocean perch and is rated as insignificant. Pacific ocean perch are fished at or below the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA Pacific ocean perch stock is expected to be insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects on the change in biomass are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect for the change in biomass is identified as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the Pacific ocean perch biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects on the spatial/temporal characteristics of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the spatial/temporal characteristics of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of GOA Pacific ocean perch and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 would have insignificant effects on Pacific ocean perch prey availability.

- **Persistent Past Effects.** Past effects on the change in prey availability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for prey availability; however, the combination of internal and external removals of prey is not expected to decrease prey availability such that the Pacific ocean perch stock is unable to sustain itself at or above MSST. Therefore, the cumulative effect of FMP 2.1 and FMP 2.2 on GOA Pacific ocean perch is considered insignificant through prey availability.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 would have insignificant effects on Pacific ocean perch habitat suitability.

- **Persistent Past Effects.** Past effects on the change in habitat suitability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in habitat suitability of GOA Pacific ocean perch are the same as those described for BSAI Pacific ocean perch under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability; however, its effect on the GOA Pacific ocean perch stock is insignificant since the combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the Pacific ocean perch stock to sustain itself at or above MSST is jeopardized.

4.6.1.12 Thornyhead Rockfish

GOA thornyhead rockfish are described in more detail in Section 3.5.1.23 of this Programmatic SEIS. Until recently, thornyhead rockfish were managed as its own stock under the GOA groundfish FMP under the Tier 3 management category, thus MSSTs are defined for these species. Beginning in 2004, thornyhead rockfish will be managed under Tier 5. GOA thornyhead rockfish were modeled under the Tier 3 category for this analysis.

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Total Biomass

Total (ages 5 through 55+) biomass of GOA thornyheads at the start of 2002 is estimated to be 54,000 mt. Model projections of future total GOA biomasses are shown in Table H.4-37 of Appendix H. Under FMP 2.1, model projections indicate that total GOA biomass is expected to remain at 54,000 mt by 2003, then slowly decrease to a value of 53,000 mt by 2007, with a 2003-2007 average value of 53,000 mt. Under FMP 2.2, model projections indicate that total GOA biomass is expected to remain at 54,000 mt by 2003, then slowly increase to a value of 55,000 mt by 2007, with a 2003-2007 average value of 54,000 mt.

Spawning Biomass

Spawning biomass of female GOA thornyheads at the start of 2002 is estimated to be 23,500 mt. Model projections of future GOA spawning biomasses are shown in Table H.4-37 and Figure H.4-16 of Appendix

H. Under FMP 2.1, model projections indicate that GOA spawning biomass is expected to increase to a value of 23,600 mt by 2003, and decreasing to 23,200 mt by 2007, with a 2002-2007 average value of 23,400 mt. Under FMP 2.2, model projections indicate that GOA spawning biomass is expected to increase to a value of 23,600 mt by 2003, and increasing to 24,300 mt by 2007, with a 2002-2007 average value of 23,900 mt.

Fishing Mortality

The average fishing mortality imposed on the GOA thornyhead stock in 2002 is projected to be 0.032 under current management. Under FMP 2.1, fishing mortality is projected to increase to 0.037 in 2003 and decrease back to 0.032 in 2007. Under FMP 2.2, fishing mortality is projected to decrease to 0.025 in 2003 and decrease further to 0.020 in 2007. These values are well below the F_{MSY} proxy value of 0.102 which is the rate associated with the OFL.

Spatial/Temporal Concentration of Fishing Mortality

Thornyhead catch is approximately evenly divided between longliners and trawlers under status quo management. There is nothing about FMP 2.1 or FMP 2.2 that is expected to change this. Longline catches are spatially dispersed along the continental shelf break throughout the GOA (Figure 4.5-1), and temporally dispersed due to the nature of the IFQ sablefish fishery. For example, longline thornyhead catches in 2000 occurred year round, with peaks in April and September which did not exceed 60 mt per week. Trawler catch has been more concentrated in time, with some catches of 20-40 mt per week happening in late spring and a single large peak of 160 mt per week in 2000 during July, coincident with the rockfish trawl fishery. Between 1997 and 1999, trawl thornyhead catches appear to have become more concentrated in space (Figure 4.5-2). The distribution of thornyheads from surveys did not appear to change over the same time period (Figure 4.5-3). This apparent concentration may be the indirect result of changes in the trawl fisheries for deepwater flatfish and rockfish since thornyheads are not a primary target of trawl fisheries. However, it should be noted that the overall catch of thornyheads is low relative to both the estimated biomass and the ABC, such that this apparent concentration of catch is unlikely to have any adverse population effects.

Status Determination

The GOA thornyhead stock is not overfished. Even at the projected low point under FMP 2.1 of 23,200 mt, spawning stock biomass is expected to be well above both $B_{35\%}$ level (14,681 mt) as well as the $B_{40\%}$ level (16,045 mt), and will remain above $B_{40\%}$ in all projection years under FMP 2.1. At 23,500 mt, spawning stock biomass under FMP 2.2 is also expected to be well above both $B_{35\%}$ level (14,681 mt) as well as the $B_{40\%}$ level (16,045 mt) in the year 2002 and will remain above $B_{40\%}$ in all projection years under FMP 2.2.

Age and Size Composition

Under FMP 2.1, the mean age of the GOA thornyhead stock in 2007, as computed in model projections (Table H.4-37 of Appendix H), is 9.90 years. Under FMP 2.2, the mean age of the GOA thornyhead stock in 2007, as computed in model projections (Table H.4-37 of Appendix H), is 10.15 years. This compares with a mean age in the equilibrium unfished GOA stock of 12.67 years.

Sex Ratio

The sex ratio of GOA thornyheads is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Under FMP 2.1, all current closed areas aside from those related to sea lion habitat would be removed. However, most current closed areas do not extend to deeper waters where thornyheads are found. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this FMP.

Under FMP 2.2, all current management measures would be maintained. The level of habitat disturbance under FMP 1 (and FMP 2.2) does not appear to affect the sustainability of thornyheads either through changes in the genetic structure of the population or changes in reproductive success, as measured by the ability of the stock to maintain itself above its MSST. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change during the next five years under this alternative.

Prey Availability

In the GOA, shortspine thornyheads prey on benthic invertebrates; according to the AFSC food habits database, much of their diet in the 1990s has been composed of shrimp. Thornyheads are rare in the diets of other groundfish, birds, or marine mammals in the GOA according to the present limited information. Therefore, the effects of FMP 2.1 and FMP 2.2 on trophic interactions involving GOA thornyheads are expected to be minor. The current levels and distribution of groundfish harvest do not appear to impact prey availability for thornyheads such that it affects the sustainability of the stock as measured by the ability of the stock to maintain itself above its MSST. Information is insufficient to conclude that existing trophic interactions would undergo significant qualitative change during the next five years under FMP 2.1 or FMP 2.2.

Summary of Effects of FMP 2.1and FMP 2.2 – GOA Thornyhead Rockfish

The GOA thornyhead stock appears to be healthy and stable under current management, and catches have generally been below the estimated ABCs because thornyheads are taken as bycatch in other directed fisheries. To the best of our knowledge, thornyheads are widely distributed in the deeper habitats of the GOA, where fishing impacts have historically been low. As long as catches remain at or near the currently observed low levels, as predicted under FMP 2.1 and FMP 2.2, we do not expect any significant population effects to thornyheads (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for GOA thornyhead rockfish are summarized in Table 4.5-22.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA thornyhead rockfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects include past foreign, JV, and domestic groundfish fisheries. The removals of thornyhead rockfish that occurred in these fisheries have had a lingering adverse effect on the populations (see Section 3.5.1.23).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause thornyhead rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of thornyhead rockfish. The IPHC longline fishery is identified as a potential adverse contributor to thornyhead rockfish mortality since they are caught as bycatch in this fishery. However, the State of Alaska shrimp fishery is identified as a non-contributing factor since thornyhead rockfish bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA thornyhead rockfish and is rated as insignificant. Fishing mortality at projected levels is well below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass Level

- **Direct/Indirect Effects.** FMP 2.1 or FMP 2.2 is expected to have insignificant effects on GOA thornyhead rockfish through the change in biomass levels.

- **Persistent Past Effects.** Past effects include past foreign, JV, and domestic groundfish fisheries. Past removals by these fisheries have had a lingering adverse effect on the GOA thornyhead rockfish populations (see Section 3.5.1.23).

- **Reasonably Foreseeable Future External Effects.** Future external effects on change in biomass level are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause thornyhead rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the thornyhead rockfish biomass level. A strong Aleutian Low and high water temperatures tend to favor recruitment whereas a weak Aleutian Low and cooler water temperatures tend to result in weak recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.23 and 3.10). The IPHC longline fishery is identified as a potential adverse contributor to the thornyhead rockfish biomass level since they are caught as bycatch in this fishery. The State of Alaska shrimp fishery is identified as a non-contributing factor since thornyhead rockfish bycatch is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the change in biomass level of GOA thornyhead rockfish and is rated as insignificant. The spawning biomass is above the B_{MSY} value for all years. The combined effect of internal removals and removals due to reasonably foreseeable

future external events is unlikely to jeopardize the capacity of the stock to sustain itself above the MSST.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 the effect of the spatial/temporal concentration of catch is considered insignificant for the stock.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of the GOA thornyhead rockfish. Climate changes and regime shifts have been identified as having a persistent past effect on the reproductive success of GOA thornyhead rockfish. Climate changes and regime shifts and corresponding water temperature variation could affect prey availability and habitat suitability, which in combination could affect the reproductive success of the thornyhead rockfish stock.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of thornyhead rockfish due to climate changes and regime shifts are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of GOA thornyhead rockfish. The IPHC longline fishery removals could be sufficiently concentrated as to alter the genetic structure and reproductive success of GOA thornyhead rockfish populations and is therefore identified as a potential adverse contributor. The State of Alaska shrimp fishery is identified as a non-contributing factor since bycatch of thornyhead rockfish is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal concentration of the thornyhead rockfish catch and is ranked as insignificant. The spatial/temporal distribution of thornyhead rockfish catch is not expected to change significantly. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above the MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1, the change in prey availability for the GOA thornyhead rockfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects include climate changes and regime shifts. Climate changes and regime shifts and corresponding water temperature variation do effect the availability of some prey species (i.e. shrimp); however, studies on benthic invertebrates have not been conducted.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA thornyhead rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain

itself above its MSST. The IPHC longline fishery is identified as a non-contributing factor since bycatch of GOA thornyhead rockfish prey species is not expected to occur in this fishery. The State of Alaska shrimp fishery is identified as a potential adverse contributor to prey availability since removal of shrimp, the main prey species of GOA thornyhead rockfish, occurs in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for the change in prey availability and is considered insignificant. The combination of internal and external removals of prey is not expected to jeopardize the ability of the stock to sustain itself above the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1, the change in habitat suitability for the GOA thornyhead rockfish is ranked as insignificant.

- **Persistent Past Effects.** Past effects identified for GOA thornyhead rockfish include climate changes and regime shifts.

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the GOA thornyhead rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fishery has been identified as a potential adverse contributor to GOA thornyhead rockfish habitat suitability (see Section 3.6). The State of Alaska shrimp fishery is identified as a non-contributing factor since habitat degradation by the shrimp fishery gear is not expected to occur.

- **Cumulative Effects.** A cumulative effect is identified for GOA thornyhead rockfish habitat suitability and is considered insignificant. The combination of internal and external habitat disturbances is not expected to lead to a detectable change in spawning or rearing success such that the ability of the thornyhead rockfish stock to sustain itself at or above the MSST is jeopardized.

4.6.1.13 Rockfish

BSAI and GOA rockfish are described in more detail in Sections 3.5.1.12-3.5.1.14 and 3.5.1.24.

BSAI Northern Rockfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Until recently, BSAI northern rockfish were managed under Tier 5; beginning in 2004, northern rockfish will be managed under Tier 3. BSAI northern rockfish were modeled under the Tier 5 category for this analysis.

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for this species.

Fishing Mortality

The catch of BSAI northern rockfish in 2003 was estimated as 6,800 mt. Projected catches from 2003-2008 are shown in Table H.4-15 of Appendix H. Under FMP 2.1, model projections indicate that the catch is

expected to decrease to 4,900 mt in 2005, then increase to 5,200 mt in 2008. The 2003-2008 average catch is 5,400 mt. Under FMP 2.2, model projections indicate that the catch is expected to decrease to 6,400 mt in 2006, then increase to 6,600 mt in 2008. The 2003-2008 average catch is 6,800 mt.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.1, model projections indicate that the average harvest of 5,400 mt from 2003-2008 occurs largely in the western Aleutian Islands (3,700 mt, 68 percent), with 800 mt (14 percent) occurring in the EBS and 700 mt (13 percent) occurring in the central Aleutians. The harvest of northern rockfish in the western Aleutian Islands is taken largely in the Atka mackerel fishery, whereas the harvest in the EBS and central Aleutians are taken in the Pacific cod and Pacific ocean perch fisheries, respectively.

Under FMP 2.2, model projections indicate that the average harvest of 6,800 mt from 2003-2008 occurs largely in the eastern Aleutian Islands (4,700 mt, 68 percent), with 1,300 mt (19 percent) occurring in the central Aleutian Islands. The harvest of northern rockfish in the each of these areas is taken largely in the Atka mackerel fishery.

Status Determination

Under FMP 2.1, the ABC for northern rockfish is set equal to the OFL. Under FMP 2.2, the catch rates are below the ABC and OFL values for all years. The MSST cannot be determined for this species.

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for this species. The sex ratio of BSAI northern rockfish is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 2.1 or FMP 2.2.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 2.1 or FMP 2.2.

Summary of Effects of FMP 2.1and FMP 2.2 – BSAI Northern Rockfish

Under FMP 2.1, the ABC for northern rockfish is set equal to the OFL. An age-structured population model for BSAI northern rockfish is not available, and projections of future OFL levels were made by carrying over the 2002 baseline values into the future. Under these assumptions, BSAI northern rockfish are equal to the OFL and the effects of mortality under FMP 2.1 are considered insignificant. Under FMP 2.2, BSAI northern

rockfish are fished at less than the ABC and the effects of mortality under FMP 2.2 are considered insignificant. Since the MSST is not able to be calculated, the spatial/temporal distribution of catch and other direct/indirect effects are unknown (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for BSAI northern rockfish are summarized in Table 4.5-23.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI northern rockfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI northern rockfish (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause northern rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of northern rockfish. The IPHC longline fishery is identified as a non-contributing factor since bycatch of BSAI northern rockfish is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI northern rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of changes in biomass level is rated as unknown since the MSST for this stock cannot be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI northern rockfish (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause northern rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the northern rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts see Sections 3.5.1.13 and 3.10. The IPHC longline fishery is identified as a non-contributing factor since bycatch of BSAI northern rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI northern rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine the MSST.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI northern rockfish. Climate changes and regime shifts are identified as having a potential beneficial/adverse effect on BSAI northern rockfish (see Section 3.5.1.13 and Section 3.10).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of northern rockfish due to climate changes and regime shifts are potential beneficial or adverse. However, climate changes and regime shifts are not expected to be sufficient to alter the genetic sub-population structure of northern rockfish. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic sub-population structure and/or the reproductive success of BSAI northern rockfish. The IPHC longline fishery has been identified as a non-contributing factor to the genetic structure and reproductive success of the other rockfish species since bycatch of this species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the northern rockfish catch; however, this effect is unknown since the MSST is not possible to be determined.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the BSAI northern rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the change in prey availability of the BSAI northern rockfish stock. The actual effect of climate changes and regime shifts on northern rockfish prey availability is unknown, but could have had a potential beneficial or adverse effect (see Sections 3.5.1.13 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI northern rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The IPHC longline fishery has been identified as a non-contributing factor since it is unlikely that bycatch of northern rockfish prey species occurs in this fishery (see Section 3.5.1.13).

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the BSAI northern rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for BSAI northern rockfish include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potential beneficial or adverse effect. The past foreign, JV, and domestic groundfish fisheries are identified as having a past adverse effect on habitat suitability, largely due to the intense bottom trawling that has occurred in northern rockfish species habitat. The IPHC longline fishery has also been identified as having had an adverse effect on northern rockfish species habitat suitability, possibly having disrupted northern rockfish species spawning and/or rearing habitats (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI northern rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fisheries have also been identified as having a potential adverse effect on the northern rockfish habitat suitability. These fisheries are expected to continue into the future and could disrupt northern rockfish species spawning and/or rearing habitats.

- **Cumulative Effects.** A cumulative effect is possible for the change in habitat suitability; however, the effect is unknown since the MSST is unable to be determined. It is unknown whether the combined effects will make the northern rockfish species vulnerable to spawning and rearing habitat disturbances due to fishing gear

BSAI Shortraker/Rougheye Rockfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Shortraker and rougheye rockfish are currently managed under Tier 5.

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for these stocks.

Fishing Mortality

The catch of BSAI shortraker/rougheye rockfish in 2003 was estimated as 900 mt. Projected catches from 2003-2008 are shown in Table H.4-16 of Appendix H. Under FMP 2.1, model projections indicate that the catch is expected to decrease to 800 mt in 2005, then increase to 1,200 mt in 2006 and remain at this level through 2008. The 2003-2008 average catch is 1,000 mt. Under FMP 2.2, the projected catch of BSAI shortraker/rougheye rockfish in each year from 2003 to 2008 was estimated as 1,000 mt.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.1,model projections indicate that the average harvest of 1,000 mt from 2003-2008 occurs largely in the central and western Aleutian Islands, with 500 and 300 mt harvested in each of these areas, respectively. The harvest of shortraker/rougheye rockfish in the central Aleutian Islands is taken largely in the Pacific ocean perch fishery, whereas the harvest in the western Aleutian Islands is taken in the Atka mackerel trawl fishery and the sablefish and Pacific cod longline fisheries.

Under FMP 2.2, model projections indicate that the average harvest of 1,000 mt from 2003-2008 occurs largely in the eastern and central Aleutian Islands, with 300 mt in each area. The harvest of shortraker/rougheye rockfish in the eastern Aleutian Islands is taken largely in the Pacific ocean perch trawl fishery, whereas the harvest in the central Aleutian Islands is taken largely in the Pacific cod longline fishery.

Status Determination

Under FMP 2.1, the ABC for shortraker/rougheye rockfish is set equal to the OFL. Under FMP 2.2, the catch rates are below the ABC and OFL values for all years. The MSST cannot be determined for these stocks

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for these species. The sex ratio of BSAI shortraker/rougheye rockfish is assumed to be 50:50. No information is available to suggest that this would change under FMP 2.1 or FMP 2.2.

Habitat Suitability

Any habitat-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that existing habitat-mediated impacts would undergo significant qualitative change under FMP 2.1 or FMP 2.2.

Prey Availability

As with habitat-mediated impacts, any predation-mediated impacts of FMP 2.1 and FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that trophic interactions would undergo significant qualitative change under FMP 2.1 or FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – BSAI Shortraker/Rougheye Rockfish

Under FMP 2.1, the ABC for shortraker/rougheye rockfish is set equal to the OFL. An age-structured population model for is not available for either shortraker or rougheye rockfish, and projections of future OFL levels were made by carrying over the 2002 baseline values into the future. The projected TAC for shortraker/rougheye rockfish from 2003-2008 is equal to the OFL, and the mortality effects under FMP 2.1 are considered insignificant. Under FMP 2.2, BSAI shortraker/rougheye rockfish are fished at less than the ABC and the effect of mortality under FMP 2.2 is considered insignificant. Since the MSST is not able to be calculated, the spatial/temporal distribution of catch and other direct/indirect effects are unknown (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects of BSAI shortraker/rougheye rockfish are summarized in Table 4.5-24.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI shortraker/rougheye rockfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI shortraker/rougheye rockfish (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shortraker/rougheye rockfish. The IPHC longline fishery and the State of Alaska shrimp fishery are identified as non-contributing factors since bycatch of BSAI shortraker/rougheye rockfish is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI shortraker/rougheye rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of changes in biomass level is rated as unknown since the MSST for this stock cannot be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on BSAI shortraker/rougheye rockfish (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the shortraker/rougheye rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts see Sections 3.5.1.13 and 3.10. The IPHC longline fishery and the State of Alaska shrimp fishery are identified as a non-contributing factors since bycatch of BSAI shortraker/rougheye rockfish species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI shortraker/rougheye rockfish, but the effect is unknown. It is unknown whether the combined effect

of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine the MSST.

- **Persistent Past Effects.** Past effects are not identified for the change in genetic structure of BSAI shortraker/rougheye rockfish. Climate changes and regime shifts are identified as having a potential beneficial/adverse effect on BSAI shortraker/rougheye rockfish (see Sections 3.5.1.13 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success of shortraker/rougheye rockfish due to climate changes and regime shifts are potential beneficial or adverse. However, climate changes and regime shifts are not expected to be sufficient to alter the genetic sub-population structure of shortraker/rougheye rockfish. Marine pollution has been identified as a potential adverse effect since acute and/or chronic pollution events could alter the genetic sub-population structure and/or the reproductive success of BSAI shortraker/rougheye rockfish. The IPHC longline fishery and State of Alaska shrimp fishery have been identified as non-contributing factors to the genetic structure and reproductive success of the other rockfish species since bycatch of this species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the shortraker/rougheye rockfish catch; however, this effect is unknown since the MSST is not possible to be determined.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the BSAI shortraker/rougheye rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as persistent past effects for the change in prey availability of the BSAI shortraker/rougheye rockfish stock. The actual effect of climate changes and regime shifts on shortraker/rougheye rockfish prey availability is unknown, but could have had a potential beneficial or adverse effect (see Sections 3.5.1.13 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI shortraker/rougheye rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. The IPHC longline fishery has been identified as a non-contributing factor since it is unlikely that bycatch of shortraker/rougheye rockfish prey species occurs in this fishery. The State of Alaska shrimp fishery is identified as a potential adverse

contributor to BSAI shortraker/rougheye prey availability since shrimp is on e of the main prey species of rougheye rockfish (see Section 3.5.1.13).

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the BSAI shortraker/rougheye rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects identified for BSAI shortraker/rougheye rockfish include climate changes and regime shifts. The actual effects of climate changes and regime shifts on habitat suitability are unknown, but could have a potential beneficial or adverse effect. The past foreign, JV, and domestic groundfish fisheries are identified as having a past adverse effect on habitat suitability, largely due to the intense bottom trawling that has occurred in shortraker/rougheye rockfish species habitat. The IPHC longline fishery has also been identified as having had an adverse effect on shortraker/rougheye rockfish species habitat suitability, possibly having disrupted shortraker/ rougheye rockfish species spawning and/or rearing habitats. The State of Alaska shrimp fishery is identified as a non-contributing factor to shortraker/rougheye rockfish habitat suitability since habitat degradation by shrimp fishery gear is not expected to occur (see Section 3.5.1.13).

- **Reasonably Foreseeable Future External Effects.** Future external effects of the climate changes and regime shifts on the BSAI shortraker/rougheye rockfish stock are potential beneficial or adverse. Marine pollution has also been identified as a potential adverse effect since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. The IPHC longline fisheries have also been identified as having a potential adverse effect on the shortraker/rougheye rockfish habitat suitability. These fisheries are expected to continue into the future and could disrupt shortraker/rougheye rockfish species spawning and/or rearing habitats.

- **Cumulative Effects.** A cumulative effect is possible for the change in habitat suitability; however, the effect is unknown since the MSST is unable to be determined. It is unknown whether the combined effects will make the shortraker/rougheye rockfish species vulnerable to spawning and rearing habitat disturbances due to fishing gear.

BSAI Other Rockfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

The other rockfish assemblage falls under Tier 5.

Total and Spawning Biomass

Reliable estimates of total and spawning biomass are not available for these species.

Fishing Mortality

Under FMP 2.1, the catch of Aleutian Islands other rockfish species in 2003 was estimated as 500 mt, increasing to 800 mt in 2004 before decreasing to 700 mt in 2008; the average catch from 2003-2008 was

700 mt. In the EBS, the projected harvest was 200 mt in 2003, decreasing to 100 mt in 2008; the average catch from 2003-2008 was projected at 100 mt. Under FMP 2.2., the catch of Aleutian Islands other rockfish in each year from 2003 to 2008 was 300 mt, and the projected harvest of EBS other rockfish was 100 mt in each of these years. Projected catches from 2003-2008 are shown in Tables H.4-1.13 and H.4-1.14 of Appendix H.

The 2003 OFL for this species complex is 846 mt and 1,280 mt in the Aleutian Islands and EBS, respectively (Reuter and Spencer 2002). Fishing mortality at projected levels under FMP 2.1 is below the OFL for other rockfish, so FMP 2.1 and FMP 2.2 are not likely to result in any significantly adverse impacts to these stocks.

Spatial/Temporal Concentration of Fishing Mortality

Under FMP 2.1, in the Aleutian Islands, 78 percent of the average harvest of 700 mt occurs in the western Aleutian Islands, taken largely in the sablefish longline fishery and Pacific cod trawl fishery. In the EBS, the average catch of 100 mt is taken largely in the Greenland turbot and sablefish longline fisheries and the flathead sole trawl fishery. Information is insufficient to determine whether existing harvest patterns would undergo any significant change under FMP 2.1.

Under FMP 2.2, in the Aleutian Islands, 85 percent of the average harvest of 300 mt occurs in the cental and western Aleutian Islands, taken largely in the Atka mackerel and Pacific cod trawl fisheries and the Pacific cod and sablefish longline fisheries. In the EBS, the average catch of 100 mt is taken largely in the Pacific cod and Greenland turbot bottom trawl fisheries and the sablefish and Greenland turbot longline fisheries. Information is insufficient to determine whether existing harvest patterns would undergo any significant change under FMP 2.2.

Status Determination

The ABC and is set equal to the OFL for this species complex under FMP 2.1. Under FMP 2.2, the fishing the ABC and is set below the OFL value. The fishing mortality rates under both FMPs are below the OFL. The MSST cannot be determined.

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for these species. Estimated sex ratios are not available for these species.

Habitat Suitability

Any habitat suitability impacts of FMP 2.1, such as adverse effects to spawning habitat, nursery grounds, benthic structures, as a result of fishing, would be governed by a complex web of direct and indirect interactions that are difficult to quantify at the present time due to insufficient data However, there is the potential for degradation of benthic habitats important to other rockfish species as a result of increased fishing for groundfish. Actions illustrated by FMP 2.1 include the repeal of all current closed areas except for those required to protect Steller sea lions. Areas now opened to groundfish fishing may result in either an increase in Other rockfish catch, or decreases depending on rockfish abundance and location of rockfish habitat. Information is insufficient to conclude at this time whether existing habitat conditions would undergo any significant change under FMP 2.1.

FMP 2.2 would retain existing closures and bycatch restrictions, so the extent that these measures protect habitat, these benefits would continue to accrue to other rockfish stocks. However, information is insufficient to conclude whether existing habitat conditions would undergo any significant change under FMP 2.2.

Prey Availability

As with habitat related impacts, any effects of FMP 2.1 or FMP 2.2 on predator-prey relationships would be governed by a complex web of direct and indirect interactions that are difficult to quantify. Information is insufficient to conclude that predator-prey relationships would undergo any significant change under FMP 2.1 or FMP 2.2.

Summary of Effects of FMP 2.1 and FMP 2.2 – BSAI Other Rockfish

Under FMP 2.1, the ABC for the other rockfish category is set equal to the OFL. An age-structured population model for is not available for either Aleutian Islands or EBS other rockfish, and projections of future OFL levels were made by carrying over the 2002 baseline values into the future. The projected TAC for other rockfish from 2003-2008 is below the OFL, and the direct and indirect effects under FMP 2.1 are considered either insignificant or unknown. The spatial/temporal distribution of catch should have no significant direct impact on stock productivity. There could be adverse effects on rockfish habitat depending on where fishing effort is directed in response to increased TACs, but there currently is insufficient information to determine the significance of these effects.

Under FMP 2.2, other rockfish are fished at less than the ABC and well below current OFL. As a result, the direct and indirect effects under FMP 2.2 are considered either insignificant or unknown. The spatial/temporal distribution of catch should have no significant direct impact on stock productivity (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects on BSAI other rockfish are summarized in Table 4.5-25.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI other rockfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects on mortality are the same as those indicated for BSAI shortraker/rougheye rockfish under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those indicated for BSAI shortraker/rougheye rockfish under this FMP.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI other rockfish and is rated as insignificant. Fishing mortality at projected levels is below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of changes in biomass level is unknown since the MSST for this stock cannot be determined.

- **Persistent Past Effects.** Past effects on the change in biomass are the same as those indicated for BSAI shortraker/rougheye rockfish under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are the same as those indicated for BSAI shortraker/rougheye rockfish under this FMP.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI other rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of the spatial/temporal concentration of catch is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects are not identified for spatial/temporal concentration of BSAI other rockfish catch.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the reproductive success and genetic structure of other rockfish are the same as those indicted for the BSAI shortraker/rougheye rockfish under these FMPs.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the other rockfish catch; however, this effect is unknown since the MSST is not possible to be determined.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in prey availability for the BSAI other rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects on the change in prey availability are the same as those indicated for BSAI shortraker/rougheye rockfish under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability are the same as those indicated for BSAI shortraker/rougheye rockfish under these FMPs.

- **Cumulative Effects.** A cumulative effect is possible for change in prey availability; however, this effect is unknown since it is not possible to determine the MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the change in habitat suitability for the BSAI other rockfish is unknown since it is not possible to determine MSST.

- **Persistent Past Effects.** Past effects on the change in habitat suitability are the same as those indicated for BSAI shortraker/rougheye rockfish under these FMPs.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in habitat suitability are the same as those indicated for BSAI shortraker/rougheye rockfish under these FMPs.

- **Cumulative Effects.** A cumulative effect is possible for the change in habitat suitability; however, the effect is unknown since the MSST is not possible to be determined. It is unknown whether the combined effect will make the other rockfish species vulnerable to spawning and rearing habitat disturbances due to fishing gear, thus the combined effects are found to be significant.

GOA Northern Rockfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

GOA northern rockfish is currently managed under Tier 3.

Total and Spawning Biomass and Fishing Mortality

FMP 2.1 represents a less precautionary approach of fishery management. An important measure in this bookend that would impact all target species is that ABC would be set equal to overfishing. This would eliminate the buffer between ABC and overfishing that exists in FMP 1. Another measure in FMP 2.1 that could impact GOA northern rockfish is that the eastern GOA trawl closure in FMP 1 would be repealed. Both of these measures in combination would likely result in a larger catch of GOA northern rockfish than has been the case in years past, and increase the risk of overfishing. However, the projection model results for this bookend indicate a decrease in GOA northern rockfish catch instead of an increase. Therefore the projection results do not appear to be reasonable. Average fishing mortality during the years 2003 - 2008 is still expected to be less than or equal to F_{OFL} (0.066) (Table H.4-35 of Appendix H).

According to the description of FMP 2.2, this FMP is much less aggressive in its approach than FMP 2.1. The two particular measures that affected GOA northern rockfish catch in FMP 2.1 (setting ABC equal to overfishing and removing the eastern GOA trawl closures) are not part of FMP 2.2, so catch of GOA northern rockfish in FMP 2.2 should be reduced relative to FMP 2.1 and result in catches similar to those of FMP 1. Instead, the bycatch model results for FMP 2.2 show lower catch for GOA northern rockfish which may be unreasonable. However, average fishing mortality during the years 2003 - 2008 is still expected to be less than F_{OFL} (0.066) (Table H.4-35 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

The effect of FMP 2.1 on the spatial/temporal concentration of northern rockfish catch is similar to what the baseline situation has been in past years. The inclusion of the eastern GOA as an open trawl zone under FMP 2.1 would not be a major difference relative to the baseline for northern rockfish. Northern rockfish generally do not occur in the eastern GOA and the trawl inclusion in this area would not affect the spatial concentration of fishing. Fishing effort would continue to be compressed into a relatively short open season resulting in

an increase risk of possible overfishing. The potential for localized depletion of the stock would also increase under the higher fishing mortality rates if fishing occurs year after year on localized aggregations of northern rockfish.

FMP 2.2 would have similar effects on the spatial/temporal concentration of northern rockfish catch as the baseline fishing. The inclusion of the eastern GOA no-trawl zone is consistent with the baseline situation. ABCs are geographically apportioned among management areas which provides some protection against localized depletion. The northern rockfish fishery would likely be concentrated into a relatively short open season, thereby increasing the risk of possible overfishing because of the difficulty of managing a short, compressed fishery. Under FMP 2.2, the potential for localized depletion of the stock exists if fishing occurs year after year on localized aggregations of northern rockfish.

Status Determination

Under FMP 2.1 and FMP 2.2, the projected B2003 of 42,700 mt is greater than $B_{35\%}$ and consequently the stock is projected to be above its MSST and not projected to be in an overfished condition. The projected B2005 of 40,300 mt under FMP 2.1, and of 40,200 mt under FMP 2.2, is greater than $B_{35\%}$ and consequently the stock is not projected to be approaching an overfished condition.

Age and Size Composition and Sex Ratio

Under FMP 2.1 and FMP 2.2, the age composition of GOA northern rockfish may be affected by fishing mortality as in FMP 1. No information is available to suggest that sex ratio would change under FMP 2.1 or FMP 2.2, but size composition of GOA northern rockfish might change in proportion to the change in age composition.

Habitat Suitability

Under FMP 2.1 and FMP 2.2, increased damage to epifauna by increased bottom trawl effort may adversely impact juvenile northern rockfish habitat. Bottom trawling or other fishing gear in contact with the ocean floor on the Gulf of Alaska continental shelf or upper slope could adversely impact juvenile northern rockfish habitat. Juvenile northern rockfish tend to live inshore in shallower depths than adults which are captured primarily between 75 - 175m. Juvenile northern rockfish may also be associated with epifauna that provides structural relief such as corals or sponges. If so, damage to this epifauna by bottom trawls may reduce survival of juvenile fish. However, there is insufficient information to conclude that habitat would undergo significant qualitative changes under FMP 2.1 or FMP 2.2.

Prey Availability

The major prey of northern rockfish is euphausiids, and northern rockfish may in turn be preyed upon by large piscivorous fish. There is insufficient information to conclude that existing trophic interactions would undergo significant qualitative change under FMP 2.1 or FMP 2.2.

Summary of Effects of FMP 2.1and FMP 2.2 – GOA Northern Rockfish

Under FMP 2.1 and FMP 2.2, average fishing mortality during the years 2003 - 2008 is expected to be less than or equal to F_{OFL}. Consequently fishing mortality is believed to have an insignificant impact on stock

sustainability. Under FMP 2.1 and FMP 2.2, the stock is projected to sustain itself at or above MSST. Consequently change in biomass is believed to have an insignificant impact on stock sustainability. Additionally, because the stock is projected to sustain itself at or above MSST, the direct effects of spatial/temporal concentration of catch on change in genetic integrity and reproductive success, as well as the indirect effects of both the change in prey availability and the change in habitat suitability are believed to have an insignificant impact on stock sustainability (Table 4.6-1).

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for GOA northern rockfish are summarized in Table 4.5-26.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA northern rockfish stock is insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects of the past foreign fisheries is identified for the GOA northern rockfish stock. Large removals of northern rockfish occurred in the past and there appears to be a lingering effect on the GOA northern rockfish populations (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch is this fishery has already been accounted for by domestic groundfish management. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are not identified as being contributors to northern rockfish mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA northern rockfish and is rated as insignificant. Northern rockfish are fished at less than the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is unlikely to jeopardize the capacity of the stock to produce MSY on a continuing basis.

Change in Biomass

- **Direct/Indirect Effects.** Change in biomass of the GOA northern rockfish stock is expected to be insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past effects of the past foreign fisheries is identified for the GOA northern rockfish stock. Large removals of northern rockfish occurred in the past and there appears to be a lingering effect on the GOA northern rockfish populations (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch is this fishery has already been accounted for by domestic groundfish management. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is

jeopardized. Climate changes and regime shifts are identified as making beneficial or adverse contributions to northern rockfish change in biomass levels as a function of change in reproductive success (see below).

- **Cumulative Effects.** A cumulative effect for the change in biomass is identified as insignificant. The combination of internal and external factors is not expected to sufficiently reduce the northern rockfish biomass such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** Impacts of the spatial/temporal changes should have an insignificant effect on the genetic structure and reproductive success of the population.

- **Persistent Past Effects.** Past effects are not identified for change in genetic structure. However, there are lingering past effects due to Climate Changes and Regime Shifts (see Section 3.5.1.24) for change in reproductive success.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since bycatch is this fishery has already been accounted for by domestic groundfish management and is not expected to contribute to changes in genetic structure or reproductive success of northern rockfish. Marine pollution is identified as having a potential adverse contribution since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock to produce MSY on a continuing basis is jeopardized. Climate changes and regime shifts are identified as potential beneficial or adverse contributor to reproductive success since changes in climate can effect prey availability and/or habitat suitability which in turn can effect recruitment. The magnitude and direction of the change in reproductive success with water temperatures is currently unknown. Climate changes and regime shifts are not considered to be contributors to change in genetic structure.

- **Cumulative Effects.** A cumulative effect is identified for the spatial/temporal and is rated as insignificant. The combination of internal and external factors is not expected to sufficiently alter the genetic structure or the reproductive success of the population such that the ability of the stock to maintain itself at or above MSST is jeopardized.

Change in Prey Availability

- **Direct/Indirect Effects.** FMP 2.1 and FMP 2.2 would have an insignificant effect on northern rockfish prey availability.

- **Persistent Past Effects.** Past climate changes and regime shifts are likely to have had lingering effects (both beneficial and adverse) on northern rockfish prey species (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has not been identified as a contributing factor since northern rockfish prey species bycatch is not expected to occur. Climate changes and regime shifts are identified as making potential beneficial or adverse

contributions on prey availability, although the magnitude and the direction of change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a reasonably foreseeable future external contributing factor since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to sustain itself above its MSST.

- **Cumulative Effects.** A cumulative effect is identified for prey availability and is rated as insignificant. The combination of internal and external removals of prey is not expected to decrease prey availability such that the northern rockfish stock is unable to sustain itself at or above MSST.

Change in Habitat Suitability

- **Direct/Indirect Effects.** FMP 2.1and FMP 2.2 would have an insignificant effect on northern rockfish habitat suitability.

- **Persistent Past Effects.** Past effects on habitat suitability identified for GOA northern rockfish stocks include past foreign, JV, and domestic fisheries, IPHC longline fishery and climate changes and regime shifts (see Section 3.5.1.24). Intense bottom trawling on northern rockfish habitat in the past fisheries likely disrupted spawning and/or rearing habitats in areas of the GOA. It is possible that some of these areas have not recovered from the intense efforts. The IPHC longline fisheries have also been identified as having adverse effects on northern rockfish habitat, although these effects are not expected to have been as intense as those effects associated with trawl gear see Section 3.6 for additional information on the effects of trawling on benthic habitat). Climate changes and regime shifts have had both beneficial and adverse effects on northern rockfish habitat.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery has been identified as an adverse contributing factor since the fishery gear could disrupt spawning and/or rearing habitats. Although, as state above, the impacts associated with longline gear are not as significant as those associated with trawl gear. Impacts on habitat from climate changes and regime shifts on the GOA northern rockfish stock are identified as potential beneficial or adverse contributors, although the magnitude and direction of the change in relation to strong and weak Aleutian Low systems are unknown. Marine pollution has also been identified as a potential adverse contributing factor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success.

- **Cumulative Effects.** A cumulative effect is identified for habitat suitability and is rated as insignificant. The combination of internal and external habitat disturbance factors is not expected to lead to a detectable change in spawning or rearing success such that the ability of the northern rockfish stock to sustain itself at or above MSST is jeopardized.

GOA Shortraker/Rougheye Rockfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

GOA shortraker/rougheye are currently managed under Tier 4 and Tier 5. Direct/indirect effects are summarized in Table 4.6-1.

Total and Spawning Biomass

No projections are possible for these two parameters, as shortraker/rougheye are classified as Tier 4 or Tier 5 species, with insufficient information to compute either parameter.

Fishing Mortality

FMP 2.1 represents a less precautionary approach of fishery management than what is currently used by the NPFMC. An important measure in this bookend that would affect all target species is that ABC would be set equal to overfishing, which would eliminate the buffer between ABC and overfishing that exists in the baseline situation and FMP 1. Another measure in FMP 2.1 that would particularly impact shortraker/ rougheye is that the eastern GOA trawl closure in FMP 1 would be repealed. Both of these measures in combination would likely result in a larger catch of shortraker/rougheye than has been the case in years past, and increase the risk of overfishing these stocks. The bycatch model results for this bookend; however, indicate catches approximately equal to those in past years, and therefore do not appear to be reasonable (Table H.4-34 of Appendix H).

FMP 2.2 is much less aggressive in its approach than FMP 2.1. The two particular measures that affected shortraker/rougheye catch in FMP 2.1 are not part of FMP 2.2, so one would expect that catch and ABC projections for shortraker/rougheye in FMP 2.2 should be nearly identical to those for FMP 1. Indeed, the ABCs for shortraker/rougheye in FMP 2.2 are the same as those in FMP 1, but the projected catches in FMP 2.2 are inexplicably higher than in FMP 1. Therefore, the catch results for shortraker/rougheye in FMP 2.2 do not seem reasonable (Table H.4-34 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 2.1 would have major effects on the spatial/temporal concentration of shortraker/rougheye catch compared to the baseline situation in past years. Because the eastern GOA trawl closure would be repealed in FMP 2.1, shortraker/rougheye would almost certainly be taken by bottom trawl again in this region. ABCs; however, would be geographically apportioned between management areas, which would continue to provide some protection against localized depletion of the resource. Because IFQs and fishing cooperatives are not part of this bookend, the trawl fisheries would likely continue to be concentrated into a relatively short open seasons. More importantly, the IFQ longline fisheries would be eliminated, and the longline fisheries would revert back to very compressed "derby" fisheries. This would increase the risk of overfishing shortraker/rougheye because of the difficulty managing these very short, intense fisheries.

FMP 2.2 would have very similar effects on the spatial or temporal concentration of shortraker/rougheye catch as has been the case for the baseline situation in past years. ABCs would be geographically apportioned between management areas, which would continue to provide some protection against localized depletion of the resource. Because IFQs or fishing cooperatives for trawl fisheries are not part of this bookend, any bycatch of shortraker/rougheye taken by trawl fisheries would likely continue to be concentrated into relatively short open seasons. Similar to the baseline, this would increase the risk of possible overfishing because of the difficulty of managing a short, compressed fishery. In contrast, FMP 2.2 would retain the IFQ system for longline fisheries, which would reduce the risk of overfishing because IFQs allow the fisheries to be spread out over an eight month season.

Status Determination

Under FMP 2.1, the ABC is set equal to the OFL. Under FMP 2.2 the catch rates are below the ABC and OFL values for all years. The MSST cannot be determined for these stocks.

Age and Size Composition and Sex Ratio

No projections are possible for these two parameters, as shortraker/rougheye are classified as Tier 4 or Tier 5 species, with insufficient information to compute either parameter. There is no information on the sex ratio of shortraker/rougheye, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 2.1 and FMP 2.2 is unknown.

Habitat Suitability

The main impacts of FMP 2.1 on habitat suitability of shortraker/rougheye would be caused by 1) increased bottom trawl activity because the bookend would increase ABCs and catches for all species, and 2) the bookend's repeal of the eastern GOA trawl closure. Increased bottom trawl activity would likely result in more damage to the benthic habitat, which could have a adverse impact on species such as shortraker and rougheye rockfish that have been observed living in association with epifauna such as corals.

Similar to FMP 1 and the baseline situation in past years, FMP 2.2 may impact habitat for shortraker/rougheye because it closes the eastern GOA to trawling. This closure prevents damage to the benthic environment in the eastern GOA because bottom trawls cannot be used. Although little is known about the habitat preferences of shortraker/rougheye, an undamaged benthic habitat may provide a benefit to these species. For example, observations from a manned submersible in the eastern GOA have found shortraker and/or rougheye rockfish associated with boulders along steep slopes (Krieger and Ito 1999) and with colonies of Primnoa coral (Krieger and Wing 2000). The eastern GOA trawl closure presumably causes a reduction in the alteration or destruction of these habitats, which may have a beneficial effect on shortraker/rougheye in this region.

Prey Availability

Pacific cod and to a lesser extent walleye pollock are species that are known to prey on shrimp, a major prey item of rougheye rockfish, so any changes in their abundance as a result of FMP 2.1 hypothetically could affect the food supply of shortraker/rougheye. Because FMP 2.1 sets ABC equal to the overfishing rate, catches of Pacific cod and walleye pollock would both increase substantially in the GOA, and their abundance would decrease. To protect Steller sea lions, FMP 2.2 has two measures that may reduce the catch and increase the abundance of Pacific cod and walleye pollock: fishing closures around sea lion rookeries, and a $B_{20\%}$ fishing rule for two species. However, whether a change in abundance of Pacific cod or walleye pollock would actually affect the food supply for shortraker/rougheye is unknown, as there is no quantitative information on trophic interactions between all these species. Moreover, shortraker and rougheye rockfish reside in deeper depths than Pacific cod or walleye pollock, so they may not be competing for the same spatial aggregations of food.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for GOA shortraker/rougheye rockfish are summarized in Table 4.5-27.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA shortraker/rougheye rockfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA shortraker/rougheye rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of shortraker/rougheye rockfish. The IPHC longline fishery and State of Alaska shrimp fishery are identified as non-contributing factors since bycatch of rockfish species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA shortraker/rougheye rockfish and is rated as insignificant. Fishing mortality at projected levels is well below OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of changes in biomass level is unknown since the MSST for this stock cannot be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA shortraker/rougheye rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause shortraker/rougheye rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the shortraker/rougheye rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.24 and 3.10). The IPHC longline fishery and State of Alaska shrimp are identified as non-contributing factors to GOA slope rockfish biomass level since bycatch is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA shortraker/rougheye rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal concentration of catch under FMP 2.1 and FMP 2.2 is unknown.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA shortraker/rougheye rockfish; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on shortraker/rougheye rockfish reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to GOA shortraker/rougheye rockfish genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, could affect reproductive success by driving changes in prey availability and habitat suitability. The IPHC longline fishery and the State of Alaska shrimp fishery are identified as non-contributing factors to the change in genetic structure and reproductive success of GOA shortraker/rougheye rockfish since bycatch in these fisheries is unlikely to occur.

- **Cumulative Effects.** A cumulative effect of the spatial/temporal characteristics of the GOA shortraker/rougheye rockfish complex is possible; however, the effect is unknown. It is unknown whether the combined effect of internal and external removals will occur in a localized manner such that it will lead to a detectable reduction in genetic diversity and reproductive success of the GOA shortraker/rougheye rockfish complex.

Change in Prey Availability

- **Direct/Indirect Effects.** The change in prey availability under FMP 2.1 and FMP 2.2 is unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on shortraker/rougheye rockfish prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to shortraker/rougheye rockfish prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10). The IPHC longline fishery is identified as a non-contributing factor to shortraker/rougheye rockfish prey availability since bycatch of shortraker/rougheye rockfish prey species is not expected to occur in this fishery. The State of Alaska shrimp fishery is identified as a potential adverse contributor to shortraker/rougheye rockfish prey availability since shrimp is a main prey item of rougheye rockfish.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA shortraker/rougheye rockfish; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The change in habitat suitability is determined to be unknown under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries, and the IPHC longline fisheries have been identified as having past persistent adverse effects on GOA shortraker/rougheye rockfish habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA shortraker/rougheye rockfish habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potential beneficial or adverse contribution to shortraker/rougheye rockfish habitat suitability (see Sections 3.5.1.24 and 3.10). The IPHC longline fishery has been identified as a potential adverse contributor to shortraker/rougheye rockfish habitat suitability due to impacts from fishery gear. The State of Alaska shrimp fishery is a non-contributing factor since habitat degradation from shrimp fishery gear is not expected to occur (see Section 3.6).

- **Cumulative Effects.** Although a cumulative effect is possible for habitat suitability of GOA shortraker/rougheye rockfish, the effect is currently unknown due to lack of scientific information.

GOA Slope Rockfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Other slope rockfish are managed under Tier 5 and sharpchin rockfish are assessed under Tier 4. Direct/indirect effects are summarized under Table 4.6-1.

Total and Spawning Biomass

No projections are possible for these two parameters, as slope rockfish species are classified as Tier 4 or Tier 5 fish, with insufficient information to compute either parameter.

Fishing Mortality

FMP 2.1 represents a less precautionary approach of fishery management than what is currently used by the NPFMC. An important measure in this bookend that would affect all target species is that ABC would be set equal to overfishing, which would eliminate the buffer between ABC and overfishing that exists in the baseline and FMP 1. An even more important measure in FMP 2.1 concerning slope rockfish is that eastern GOA trawl closure would be repealed. Because slope rockfish mostly reside in the eastern GOA and are predominantly caught by trawl, opening this region to trawling would make most of GOA population of slope rockfish vulnerable to fishing. Both of these measures in combination would result in a larger catch of slope rockfish than has been the case in years past, and increase the risk of overfishing slope rockfish stocks. The model results for this bookend indicate a modest increase in slope rockfish catch of about 300-400 mt

compared to the baseline and FMP 1 and recent past catches, but it is likely that if FMP 2.1 actually went into effect, catches of slope rockfish would show even more of an increase (Table H.4-31 of Appendix H).

FMP 2.2 is much less aggressive in its approach than FMP 2.1. The two particular measures that affected slope rockfish catch in FMP 2.1 (removing the eastern GOA trawl closures and setting ABC equal to overfishing) are not part of FMP 2.2, so one would expect that catch and ABC projections for slope rockfish in FMP 2.2 should be nearly identical to those for FMP 1. The model results for FMP 2.2; however, show ABCs for slope rockfish much less than for those FMP1, and the corresponding catch projections are inexplicably similar to FMP 2.1. Thus, ABC and catch results for slope rockfish in the model for FMP 2.2 do not appear reasonable (Table H.4-31 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 2.1 would have substantial effects on the spatial or temporal concentration of slope rockfish catch, especially because the eastern GOA trawl closure would be rescinded. This would allow trawling for rockfish species in the eastern GOA, where most of the GOA population of slope rockfish is located, and greatly increase the chance of localized depletion for some of the slope rockfish species. Because IFQs and fishing cooperatives are not part of this bookend, catches of slope rockfish would likely continue to be concentrated into relatively short open seasons when fishing for rockfish is allowed. Similar to the baseline and FMP 1, this would increase the risk of possible overfishing slope rockfish species because of the difficulty of managing a short, compressed fishery.

FMP 2.2 would have very similar effects on the spatial or temporal concentration of slope rockfish catch as has been the case for the baseline situation in past years. There have been no studies to determine stock structure for any species of slope rockfish, and it is unknown if subpopulations exist. Consequently, there is a possibility that localized depletion may be occurring, despite the effort of geographic apportionment. However, because most of the biomass of slope rockfish occurs in the eastern GOA, which is closed to trawling in this FMP, localized depletion is unlikely under this FMP.

There are no measures in FMP 2.2 for IFQs or cooperatives for rockfish trawlers, who historically have taken most of the catch of slope rockfish in the form of bycatch. Because these measures do not exist in this FMP, it is likely that the rockfish trawl fishery would continue to be compressed into a short open season each year. This would cause a greater risk of possibly overfishing slope rockfish, because it is difficult to manage the fishery within this short time span.

Status Determination

No projections are possible for the fishing mortality rate or MSST, as slope rockfish species are classified as Tier 4 or Tier 5 fish, with insufficient information to compute either parameter.

Age and Size Composition and Sex Ratio

Age and size composition estimates are not available for these species. There is no information on the sex ratio of slope rockfish, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 2.1 or FMP 2.2 is unknown.

Habitat Suitability

The main impacts of FMP 2.1 on habitat suitability of slope rockfish would be caused by 1) the bookend's repeal of the eastern GOA trawl closure, and 2) increased bottom trawl activity because the bookend would increase ABCs and catches for all species by setting ABC equal to overfishing. The removal of the eastern GOA trawl closure would permit bottom trawlers to catch slope rockfish in the eastern GOA, where most of the slope rockfish biomass is located, and this region would no longer serve as a *de facto* refugium for slope rockfish species. Increased bottom trawl activity would likely result in more damage to benthic habitats, and therefore could have a adverse impact on slope rockfish. The impact could be especially acute for juvenile slope rockfish, which may be particularly dependent on such epifauna.

Similar to FMP 1, FMP 2.2 greatly impacts habitat for slope rockfish because it closes the eastern GOA to trawling. This creates a *de facto* no-take zone or refugium for slope rockfish in this area, as trawls are generally the only effective gear for capturing most of these species.

Prey Availability

No studies have been done in Alaska to determine the food habits for any of the slope rockfish species. Many of the abundant species, such as sharpchin, harlequin, and redstripe rockfish, are relatively small in size and may be plankton-feeders, but this is conjecture. There is also no documentation of predation on slope rockfish, although larger fishes such as Pacific halibut that are known to prey on other rockfish presumably also prey on slope rockfish. Because of this lack of information, the effect of FMP 2.1 and FMP 2.2 on predator-prey relationships for slope rockfish is unknown.

Cumulative Effects of FMP 2.1 FMP 2.2

Cumulative effects of GOA slope rockfish are summarized in Table 4.5-28.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA other slope rockfish is rated as insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries and State of Alaska groundfish fisheries have been identified as having had a adverse persistent past effect on GOA other slope rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to the potential adverse effects of marine pollution since acute and/or chronic pollution events could cause other slope rockfish mortality. Climate changes and regime shifts are considered non-contributing factors since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of other slope rockfish. The State of Alaska groundfish fisheries is identified as a non-contributing factor since catch and bycatch of slope rockfish species is already accounted for by the domestic groundfish fishery management. The IPHC longline fishery is also identified as a non-contributing factor since bycatch of slope rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA other slope rockfish and is rated as insignificant. Fishing mortality at projected levels is equal to or below the OFL for this stock. The combined effect of internal removals and removals due to reasonably foreseeable future external events is unlikely to jeopardize the capacity of the stock maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, the effect of changes in biomass level is unknown since the MSST for this stock cannot be determined.

- **Persistent Past Effects.** Due to large harvest rates and the longevity of rockfish, past foreign, JV, and domestic fisheries have been identified as having had a adverse persistent past effect on GOA other slope rockfish stocks (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are indicated due to potential adverse effects of marine pollution since acute and/or chronic pollution events could cause other slope rockfish mortality. Climate changes and regime shifts have also been identified as having potential beneficial or adverse effects on the other slope rockfish biomass level; however, it is unknown whether warmer water temperatures will favor or reduce recruitment. For more information on climate changes and regime shifts (see Sections 3.5.1.24 and 3.10). The State of Alaska groundfish fisheries are identified as non-contributing factors to GOA slope rockfish biomass level. Although catch and bycatch do occur in these fisheries, the removals are already accounted for by the domestic groundfish fishery management.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of GOA other slope rockfish, but the effect is unknown. It is unknown whether the combined effect of internal and external removals is likely to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The spatial/temporal concentration of catch under FMP 2.1and FMP 2.2 is unknown.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA slope rockfish; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on slope rockfish reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to GOA slope rockfish genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic

structure; however, could affect reproductive success by driving changes in prey availability and habitat suitability. The State of Alaska groundfish fishery is identified as a non-contributing factor to the change in genetic structure and reproductive success of GOA slope rockfish. Although catch and bycatch of slope rockfish species occurs in these fisheries, they are not expected to contribute to localized depletion such that it leads to a detectable reduction in genetic diversity or reproductive success. The IPHC longline fishery is also identified as a non-contributing factor since bycatch of slope rockfish species is not expected to occur in this fishery.

- **Cumulative Effects.** A cumulative effect of the spatial/temporal characteristics of the GOA slope rockfish complex is possible; however, the effect is unknown. It is unknown whether the combined effect of internal and external removals will occur in a localized manner such that it will lead to a detectable reduction in genetic diversity and reproductive success of the GOA slope rockfish complex.

Change in Prey Availability

- **Direct/Indirect Effects.** The change in prey availability under FMP 2.1 and FMP 2.2 is unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on slope rockfish prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** Marine pollution is identified as a potential adverse contributor to slope rockfish prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10). The State of Alaska groundfish fishery and the IPHC longline fishery are identified as non-contributing factors to slope rockfish prey availability since bycatch of slope rockfish prey species is not expected to occur in these fisheries.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA slope rockfish; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The change in habitat suitability is determined to be unknown under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries, State of Alaska groundfish fisheries and the IPHC longline fisheries have been identified as having past persistent adverse effects on GOA slope rockfish habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA slope rockfish habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime

shifts could make a potential beneficial or adverse contribution to slope rockfish habitat suitability. The State of Alaska groundfish fishery and the IPHC longline fishery have been identified as potential adverse contributors to slope rockfish habitat suitability due to impacts from fishery gear (see Section 3.6).

- **Cumulative Effects.** Although a cumulative effect is possible for habitat suitability of GOA slope rockfish, the effect is currently unknown due to lack of scientific information (Table 4.5-28).

GOA Pelagic Shelf Rockfish – Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Until recently, dusky rockfish fell under Tier 4, while yellowtail and widow rockfish were managed under Tier 5. As of 2004, dusky rockfish will be managed under Tier 3 and the rest of the pelagic rockfish species will continue under Tier 5 until more information becomes available. GOA dusky rockfish were modeled under the Tier 4 category for this analysis. Direct/indirect effects are summarized in Table 4.6-1.

Total and Spawning Biomass

No projections are possible for these two parameters, as PSR species are classified as Tier 4 or Tier 5 fish and an age-structured model has not been finalized for dusky rockfish.

Fishing Mortality

FMP 2.1 represents a less precautionary approach of fishery management than what is currently used by the NPFMC. An important measure in this bookend that would affect all target species is that ABC would be set equal to overfishing, which would eliminate the buffer between ABC and overfishing that exists in the baseline situation and FMP 1. Another measure in FMP 2.1 that would particularly impact PSR is that the eastern GOA trawl closure in FMP 1 would be repealed. Both of these measures in combination would likely result in a larger catch of PSR than has been the case in years past, and increase the risk of overfishing PSR stocks. The model results for this bookend; however, indicate a decrease in PSR catch, instead of an increase, and therefore do not appear to be reasonable (Table H.4-32 of Appendix H).

According to the description of FMP 2.2, this FMP is much less aggressive in its approach than FMP 2.1. The two particular measures that affected PSR catch in FMP 2.1 (setting ABC equal to overfishing and removing the eastern GOA trawl closures) are not part of FMP 2.2, so one would expect that catch and ABC projections for PSR in FMP 2.2 should be nearly identical to those for FMP 1. Instead, the model results for FMP 2.2 show ABCs for PSR substantially less than for those FMP 1, and the corresponding catch projections are inexplicably similar to FMP 2.1. Thus, catch and ABC results for PSR in the model for FMP 2.2 appear highly unreasonable (Table H.4-32 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

FMP 2.1and FMP 2.2 would have very similar effects on the spatial or temporal concentration of PSR catch as has been the case for the baseline situation in past years. ABCs would be geographically apportioned between management areas, which would continue to provide some protection against localized depletion of the resource. Because rockfish IFQs and fishing cooperatives are not part of these bookends, the PSR fishery would likely continue to be concentrated into a relatively short open season. Similar to the baseline

and FMP 1, this would increase the risk of possible overfishing because of the difficulty of managing a short, compressed fishery.

Status Determination

Under FMP 2.1, the ABC is set equal to the OFL. Under FMP 2.2, the catch rates are below the ABC and OFL values. The MSST cannot be determined at this time for these stocks.

Age and Size Composition and Sex Ratio

No projections are possible for these two parameters, as PSR species are classified as Tier 4 or Tier 5 fish and an age-structured model has not been finalized for dusky rockfish. There is no information on the sex ratio of PSR, although sex ratio for many other species of *Sebastes* has been reported to be approximately 50:50. How the sex ratio may be affected by FMP 2.1 or FMP 2.2 is unknown.

Habitat Suitability

The main impacts of FMP 2.1 on habitat suitability of PSR would be caused by 1) increased bottom trawl activity because the bookend would increase ABCs and catches for all species, and 2) the bookend's repeal of the eastern GOA trawl closure. Increased bottom trawl activity would likely result in more damage to the benthic habitat, which could have a adverse impact on PSR such as dusky rockfish that may live in association with epifauna such as corals or sponges. The impact could be especially acute for juvenile dusky rockfish, which may be particularly dependent on such epifauna. The removal of the eastern GOA trawl closure would permit bottom trawlers to catch PSR in the eastern GOA, and this region would no longer serve as a *de facto* refugium that could help to replenish PSR stocks in other areas of the GOA.

Similar to FMP 1 and the baseline situation in past years, FMP 2.2 impacts habitat for PSR because it closes the eastern GOA to trawling. This creates a *de facto* no-take zone or refugium for PSR in this area, as trawls are generally the only effective gear for capturing these species. Although biomass estimates from trawl surveys indicate that the trawl closure area in the eastern GOA only contains about 10-15 percent of the Gulfwide biomass of dusky biomass, this is still large enough that it may provide enhanced protection to the dusky rockfish resource.

Prey Availability

The major prey of dusky rockfish appears to be euphausiids, based on the limited food information available for this species (Yang 1993). Euphausiids are also the major prey of walleye pollock, which means dusky rockfish and walleye pollock may be competing for the same food resource. Thus, any measures in FMP 2.1 that affect the commercial catch of walleye pollock could have an subsequent indirect effect on dusky rockfish by increasing or decreasing the amount of euphausiids available to dusky rockfish. Because this bookend sets ABC equal to the overfishing rate, catches of walleye pollock would increase substantially in the GOA. This would decrease the abundance of walleye pollock, and hypothetically increase the number of euphausiids available for consumption by dusky rockfish. To protect Steller sea lions, FMP 2.2 (similar to FMP 1 and the baseline situation in past years) has two measures that may reduce catch of walleye pollock: fishing closures around sea lion rookeries, and a $B_{20\%}$ fishing rule for walleye pollock. Hypothetically, these two measures could increase the abundance of walleye pollock, resulting in the consumption of more euphausiids and having an adverse effect on the food supply for dusky rockfish.

However, there is little or no quantitative information on trophic interactions between dusky rockfish and walleye pollock or data on whether they even feed on the same spatial aggregations of euphausiids. Therefore, the effects of FMP 2.1 and FMP 2.2 on GOA PSR is unknown through the change in prey availability.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects for the GOA PSR complex are summarized in Table 4.5-29.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA PSR complex is insignificant under FMP 2.1 and FMP 2.2.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA PSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR mortality since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR mortality since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to PSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for mortality of GOA PSR and is rated as insignificant. PSR are expected to be fished at or below the OFL. The combined effect of internal removals and removals due to reasonably foreseeable external events is not expected to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** The effects of FMP 2.1 and FMP 2.2 on the biomass level are unknown.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp and fishery has been identified as a non-contributing factor to GOA PSR biomass levels since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR mortality since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to PSR mortality.

- **Cumulative Effects.** A cumulative effect is identified for change in biomass; however, the effect is unknown since total and spawning biomass levels and MSST are currently unavailable.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The effects of the fisheries on the spatial/temporal characteristics of GOA PSR under FMP 2.1 and FMP 2.2 are unknown.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA PSR; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on PSR reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp and fishery has been identified as a non-contributing factor to GOA PSR genetic structure and reproductive success since bycatch in this fishery is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA PSR genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, could affect reproductive success by driving changes in prey availability and habitat suitability.

- **Cumulative Effects.** A cumulative effect of the spatial/temporal characteristics of the GOA PSR complex is possible; however, the effect is unknown.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in prey availability under FMP 2.1 and FMP 2.2 is currently unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on PSR prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a potential adverse contributor to GOA PSR prey availability. The catch of shrimp in the shrimp fishery is expected to continue in the future. Marine pollution is identified as a potential adverse contributor to PSR prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10).

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA PSR; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in habitat suitability under FMP 2.1 and FMP 2.2 is currently unknown.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries have been identified as having past persisting adverse effects on GOA PSR habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA PSR habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska shrimp fishery has been identified as a non-contributing factor to GOA PSR habitat suitability since the gear associated with this fishery is not expected to cause a significant impact to the benthic habitat (see Sections 3.5.1.24 and 3.6). Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potential beneficial or adverse contribution to DSR habitat suitability (see Sections 3.5.1.24 and 3.10).

- **Cumulative Effects.** Although a cumulative effect is possible for habitat suitability of GOA PSR, the effect is currently unknown due to lack of scientific information.

GOA Demersal Shelf Rockfish – Direct/Indirect Effects of FMP 2.1

Demersal shelf rockfish are managed under Tier 4. Direct/indirect effects are summarized in Table 4.6-1.

Total and Spawning Biomass

Reliable total and spawning biomass statistics are not available for demersal shelf rockfish species. However, due to the removal of DSR bycatch and halibut IFQ program under this FMP, it is likely that the biomass of DSR will likely tend toward levels that jeopardize the ability of the stock to sustain itself at or above current population levels. Therefore, the direct/indirect effects of FMP 2.1 are ranked as significantly adverse for change in biomass.

Fishing Mortality

The catch (fishing mortality) of DSR in the eastern GOA would reach and likely exceed the DSR OFL, or 540 mt under this example FMP. It is presumed that managers would continue to set TAC below its ABC level to prevent the directed catch and the bycatch of DSR in the halibut fishery to exceed the OFL. It is unknown whether a directed fishery for DSR would be permitted under FMP 2.1 since this management plan would permit the reopening of the eastern GOA to trawl fishing. Historically trawl fisheries in this area have targeted Pacific ocean perch and other pelagic rockfish species. Bycatch of DSR in a trawl fishery is likely but would be difficult to estimate in advance. Mortality approaching 540 mt would raise serious management concerns about the sustainability of the population to withstand such a high exploitation rate. Recent investigations on rockfish exploitation strategies on the west coast of the U.S. suggest that a lower F50 value may be more appropriate for long-lived rockfish stocks than the current F40 rate. (Ralston *et al.* 2002; Ralston (1998); and Dorn (2002). Increasing the mortality level to 540 mt is the equivalent to a F35 exploitation rate. Nearing or exceeding this level would be detrimental to DSR. We conclude that the

projected catch of the FMP 2.1 scenario would result in a significantly adverse effect (Table H.4-33 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

In the eastern GOA, most of the DSR harvest is taken in the southeast Outside District with the remainder taken from the east Yakutat Districts (O'Connell *et al.* 2002). We would expect a similar geographic distribution of DSR catch under FMP 2.1. However, as described above, localized deception of DSR stocks could be occurring within these districts. Due to the uncertainty that such localized depletion is occurring on the Fairweather Grounds (or elsewhere), we conclude that management under FMP 2.1 would have a conditionally significant adverse effect on the current environmental condition of DSR stocks in the eastern GOA.

Status Determination

The MSST cannot be determined for this stock complex.

Age and Size Composition and Sex Ratio

Age and size composition data is not available for GOA demersal shelf rockfish species. The sex ratio of GOA demersal shelf rockfish species is unknown.

Habitat Suitability

Any habitat suitability impacts of FMP 2.1, such as adverse effects to spawning habitat, nursery grounds, benthic structures, as a result of fishing, would be governed by a complex web of direct and indirect interactions that are difficult to quantify. However, under this example FMP, trawl fisheries would again be permitted to operate in the eastern GOA for the first time in years. Information is insufficient to conclude where these fisheries would occur and whether existing habitat-related impacts would undergo significant change under FMP 2.1. Due to the uncertainty about the intensity of these effects, we have concluded that FMP 2.1 would have a conditionally significant adverse effect on the current environmental condition of DSR habitat.

Prey Availability

Any predator-prey impacts of FMP 2.1 would be governed by a complex web of direct and indirect interactions that are difficult to quantify due to inadequate data. Information is insufficient to conclude that predator-prey relationships would undergo any significant change under FMP 2.1. Therefore, the effects of FMP 2.1 on GOA DSR through prey availability are unknown.

Summary of Effects of FMP 2.1 – GOA Demersal Shelf Rockfish

Under FMP 2.1, the ABC for DSR rockfish is set equal to the OFL. An age-structured population model is not used for DSR rockfish and projections of future OFL levels were made by carrying the 2002 baseline values into the future. The projected TAC for DSR rockfish from 2003-2008 will be set below the OFL to prevent overfishing when taking into account any unreported catch, or bycatch mortality. However, combining all estimates of direct mortality raises the risk of overfishing DSR, especially since this FMP

would eliminate the DSR bycatch limits in the halibut fishery and authorize renewed trawl operations in the eastern GOA. The uncertainties of the location, magnitude, or bycatch of DSR species in these fisheries has led us to conclude that there would be significantly adverse effects of this FMP on DSR species. Similarly, conditionally significant adverse effects resulting from localized depletion and habitat degradation are possible.

Cumulative Effects of FMP 2.1

Cumulative effects for the DSR complex are summarized in Table 4.5-30.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA DSR complex is significantly adverse under FMP 2.1.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and the IPHC longline fishery have been identified as non-contributing factors to GOA DSR mortality since catch/bycatch in these fisheries is already accounted for by the domestic fishery management levels or bycatch is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA DSR mortality since acute and/or chronic pollution events, if large enough in scale, could cause mortality to the point that the capacity of the stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to DSR mortality.

- **Cumulative Effects.** A significantly adverse cumulative effect is identified for mortality of GOA DSR. The elimination of the DSR bycatch limits in the halibut fishery and renewed fishery operations in the eastern GOA increase the risk of overfishing. The combined effect of internal removals and removals due to reasonably foreseeable external events is expected to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** It is determined the effect of the fisheries on change in biomass level under FMP 2.1 is significantly adverse.

- **Persistent Past Effects.** Removals by past foreign, JV, and domestic fisheries are identified as having a lingering adverse effect on the GOA DSR population (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and the IPHC longline fishery have been identified as non-contributing factors to GOA DSR biomass levels since catch/bycatch in these fisheries is already accounted for by the domestic fishery management levels or bycatch is not expected to occur. Marine pollution is identified as a potential adverse contributor to GOA DSR mortality since acute and/or chronic pollution events, if large enough in scale, could impact biomass to the point that the capacity of the

stock complex to maintain current population levels is jeopardized. Climate changes and regime shifts are not identified as being contributors to DSR mortality.

- **Cumulative Effects.** A significantly adverse cumulative effect is identified for change in biomass. The elimination of the DSR bycatch limits in the IPHC fishery and the reopening of trawl operations in the eastern GOA could reduce biomass levels. The combined effects of internal and external removals is expected to jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** The effect of the fisheries on the spatial/temporal characteristics of GOA DSR are identified as conditionally significant adverse.

- **Persistent Past Effects.** No persistent past effects have been identified for the change in genetic structure of GOA DSR; however, climate changes and regime shifts have been identified as having had potential beneficial or adverse effects on DSR reproductive success. Climate changes and regime shifts influence prey availability and habitat suitability which in combination effect reproductive success (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring, shrimp and groundfish fisheries and IPHC longline fisheries have been identified as non-contributing factors to GOA DSR genetic structure and reproductive success. Catch/bycatch of these fisheries is already accounted for by the domestic groundfish management or is not expected to occur (as in the case of the State of Alaska herring and shrimp fisheries). Marine pollution is identified as a potential adverse contributor to GOA DSR genetic structure and reproductive success since acute and/or chronic pollution events, depending on their location and magnitude, could alter the genetic structure of the population through localized mortality events, and also could result in reduced recruitment. Climate changes and regime shifts are identified as non-contributing factors to genetic structure; however, could affect reproductive success by driving changes in prey availability and habitat suitability.

- **Cumulative Effects.** The concentration of fishing in the Fairweather Grounds and the reopening of the eastern GOA to trawl operations could have significantly adverse effects on the current environmental condition of DSR stocks in the eastern GOA. The combined effects of internal and external removals are likely to jeopardize the ability of the stock complex to maintain current population sizes, therefore a rating of conditionally significant adverse is assigned to change in genetic structure and reproductive success of GOA DSR.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in prey availability under FMP 2.1 is currently unknown.

- **Persistent Past Effects.** Climate changes and regime shifts have been identified as having had beneficial or adverse effects on DSR prey availability (see Sections 3.5.1.24 and 3.10).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring and shrimp fisheries have been identified as potential adverse contributors to GOA DSR prey availability. Catch of herring in the herring fishery and the catch of shrimp in the shrimp fishery are expected to continue in the future. The State of Alaska groundfish fishery and the IPHC longline fishery are identified as non-contributing factors to GOA DSR prey availability since bycatch of DSR prey species in not expected to occur. Marine pollution is identified as a potential adverse contributor to DSR prey availability since acute and/or chronic pollution events could reduce prey availability or prey quality such that the ability of the stock complex to maintain itself at current population levels is jeopardized. Climate changes and regimes shifts are identified as potential beneficial or adverse contributors to prey availability (see Sections 3.5.1.24 and 3.10).

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA DSR; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Due to the potential increase in fishing effort as a result of the removal of DSR bycatch limits and the halibut IFQ program, we have determined FMP 2.1 to have a conditionally significant adverse effect on DSR habitat suitability.

- **Persistent Past Effects.** Past foreign, JV, and domestic groundfish fisheries and the IPHC longline fisheries have been identified as having past persisting adverse effects on GOA DSR habitat due to the impacts caused by fishery gear. Climate changes and regime shifts have also been identified as having past beneficial or adverse effects on GOA DSR habitat suitability (see Section 3.5.1.24).

- **Reasonably Foreseeable Future External Effects.** The State of Alaska herring and shrimp fisheries have been identified as non-contributing factors to GOA DSR habitat suitability since the gear associated with these fisheries are not expected to cause a significant impact to the benthic habitat. The State of Alaska groundfish fisheries and the IPHC longline fisheries are identified as potential adverse contributors to DSR habitat suitability (see Sections 3.5.1.24 and 3.6). Marine pollution has been identified as a potential adverse contributor since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Climate changes and regime shifts could make a potential beneficial or adverse contribution to DSR habitat suitability (see Sections 3.5.1.24 and 3.10).

- **Cumulative Effects.** A conditionally significant adverse cumulative effect is identified for change in habitat suitability of the GOA DSR. The reopening of the eastern GOA trawl operations in combination with external removals are likely to jeopardize the capacity of the GOA DSR complex to maintain current populations.

Direct/Indirect Effects of FMP 2.2

Total and Spawning Biomass

Reliable total and spawning biomass statistics are not available for demersal shelf rockfish species. However, due to the removal of the DSR bycatch levels and the removal of the halibut IFQ, the increase in DSR mortality could significantly reduce the DSR biomass to a level at which the capacity of DSR species to

maintain current population levels is jeopardized. Thus, FMP 2.2 is rated as conditionally significant adverse for change in biomass.

Fishing Mortality

The projected catch of DSR rockfish would likely be a little lower under this FMP than FMP 2.1. DSR ABC levels would be set below the OFL to prevent overfishing. While a reduced ABC, and in turn a reduced TAC for DSR species would reduce the risk of overfishing, the removal of bycatch limits in the halibut fishery and the addition of trawl fisheries permitted by this FMP would likely offset any benefits of reduced ABCs. As described for FMP 2.1, mortality of DSR species would likely increase above current levels. Mortality approaching 540 mt would raise serious management concerns about the sustainability of the population to withstand such the higher exploitation rate. Recent investigations on rockfish exploitation strategies suggest that a lower F50 value may be more appropriate for long-lived rockfish stocks than the current F40 rate. (Ralston 1998, 2002, and Dorn 2002). Increasing the mortality to 540 mt is the equivalent to a F35 exploitation rate. Nearing or exceeding this level would be detrimental to DSR. We conclude that the projected catch of the FMP 2.2 scenario would result in a significantly adverse effect on DSR species (Table H.4-33 of Appendix H).

Spatial/Temporal Concentration of Fishing Mortality

In the eastern GOA, most of the DSR harvest is taken in the southeast Outside District with the remainder taken from the east Yakutat District (O'Connell *et al.* 2002). We would expect a similar geographic distribution of DSR catch under FMP 2.2. However, as described previously for FMP 2.1, localized deception of DSR stocks could be occurring within these districts. Due to the uncertainty that such localized depletion is occurring on the Fairweather Grounds (or elsewhere), we conclude that management under FMP 2.2 would have a conditionally significant adverse effect on the current environmental condition of DSR stocks in the eastern GOA.

Status Determination

The MSST cannot be determined for this stock complex.

Age and Size Composition and Sex Ratio

Age and size composition data is not available for GOA demersal shelf rockfish species. The sex ratio of GOA demersal shelf rockfish species is unknown.

Habitat Suitability

Any habitat suitability impacts of FMP 2.2, such as adverse effects to spawning habitat, nursery grounds, benthic structures, as a result of fishing, would be governed by a complex web of direct and indirect interactions that are difficult to quantify due to inadequate data. However, unlike FMP 2.1, the trawl closure currently in place for the eastern GOA would remain, thereby maintaining the current level of habitat protection from this gear type. Due to the uncertainty about the intensity of these effects, we have concluded that FMP 2.2 would have a conditionally significant adverse effect on the current environmental condition of DSR habitat.

Prey Availability

Any effects to predator-prey relationships of FMP 2.2 would be governed by a complex web of direct and indirect interactions that are difficult to quantify due to inadequate data. Information is insufficient to conclude that predator-prey relationships would undergo any significant change under FMP 2.2.

Summary of Effects of FMP 2.2 – GOA Demersal Shelf Rockfish

Under FMP 2.2, the ABC for DSR rockfish is set less than the OFL. An age-structured population model is not used for DSR rockfish and projections of future OFL levels were made by carrying the 2002 baseline values into the future. The projected TAC for DSR rockfish from 2003-2008 will be set below the OFL to prevent overfishing when taking into account any unreported catch, or bycatch mortality. However, combining all estimates of direct mortality raises the risk of overfishing DSR, especially since this FMP eliminates bycatch limits in the halibut fishery and would authorize renewed trawl operations in the eastern GOA. The uncertainties of the location, magnitude, or bycatch of DSR species in these fisheries has led us to conclude that there would be conditionally significant adverse effects of this FMP on DSR species. The effects to predator-prey relationships are unknown .

Cumulative Effects of FMP 2.2

Cumulative effects for the GOA DSR complex are summarized in Table 4.5-30.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the GOA DSR complex is significantly adverse under FMP 2.2.

- **Persistent Past Effects.** Past effects on mortality are the same as those indicated under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on mortality are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A significantly adverse cumulative effect is identified for mortality of GOA DSR. The elimination of the DSR bycatch limits in the halibut fishery and increase of fishing effort in the eastern GOA increases the risk of overfishing. The combined effect of internal removals and removals due to reasonably foreseeable external events is expected to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass

- **Direct/Indirect Effects.** FMP 2.2 is rated as conditionally significant adverse for change in biomass levels.

- **Persistent Past Effects.** Past effects on the change in biomass are the same as those indicated under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in biomass are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A conditionally significant adverse cumulative effect is identified for change in biomass. If DSR bycatch limits in the IPHC fishery are eliminated, the increase of fishing effort in the eastern GOA could reduce biomass levels. Under those conditions, he combined effects of internal and external removals could jeopardize the capacity of the stock to maintain current population levels.

Spatial/Temporal Concentration of Catch

- Change in Genetic Structure of Population
- Change in Reproductive Success

- **Direct/Indirect Effects.** FMP 2.2 is rated as conditionally significant adverse for the spatial/temporal characteristics of GOA DSR under FMP 2.2.

- **Persistent Past Effects.** Past effects on the change in reproductive success and genetic structure of the GOA DSR are the same as those indicated under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in reproductive success and genetic structure of the GOA DSR are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** The concentration of fishing in the Fairweather Grounds and the increased trawl operations in the eastern GOA could have conditionally significant adverse effects on the current environmental condition of DSR stocks in the eastern GOA. The combined effects of internal and external removals are likely to jeopardize the ability of the stock complex to maintain current population sizes, therefore a rating of conditionally significant adverse is assigned to change in genetic structure and reproductive success of GOA DSR.

Change in Prey Availability

- **Direct/Indirect Effects.** The effect of the fisheries on the change in prey availability under FMP 2.2 is unknown.

- **Persistent Past Effects.** Past effects on the change in prey availability of the GOA DSR are the same as those indicated under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in prey availability of the GOA DSR are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is possible for the change in prey availability of the GOA DSR; however, the effect is unknown due to lack of scientific information.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Due to the potential increase in fishing effort as a result of the removal of DSR bycatch limits and the halibut IFQ program, we have determined FMP 2.2 to have a conditionally significant adverse effect on DSR habitat suitability.

- **Persistent Past Effects.** Past effects on the change in habitat suitability of the GOA DSR are the same as those indicated under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Future external effects on the change in habitat suitability of the GOA DSR are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A conditionally significant adverse cumulative effect is identified for change in habitat suitability of the GOA DSR. The increased trawling efforts in eastern GOA in combination with external removals are likely to jeopardize the capacity of the GOA DSR complex to maintain current populations.

4.6.2 Prohibited Species Alternative 2 Analysis

4.6.2.1 Pacific Halibut

Pacific halibut are managed by the International Pacific Halibut Commission (IPHC). Halibut bycatch in Federal groundfish fisheries is controlled by the use of PSC limits. IPHC provides for all removals of halibut, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, changes in bycatch (increase or decrease) are reflected in changes to quotas set for the directed fishery.

FMP 2.1 and FMP 2.2 – Direct/Indirect Effects

Direct and indirect effects for Pacific halibut include mortality along with changes in reproductive success and prey availability. These effects, which are associated with changes in catch, are considered insignificant because annual quota setting processes implemented by IPHC account for all removals of halibut including bycatch in other fisheries. Thus, if changes to the baseline condition of the stock occur, they are reflected in the quotas set for the directed fishery. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. Halibut are opportunistic predators with a wide range of prey species, and no significant change to prey structure is expected as a result of FMP 2.1 or 2.2. No evidence of fishery impact to habitat of halibut has been shown, so this effect will not be considered in the cumulative effects analysis that follows.

Under FMP 2.1, halibut PSC caps would be removed. Halibut bycatch mortality in the BSAI and GOA combined would increase from the present 6,800 mt to 12,000-15,000 mt as a result of increases in TAC levels for target groundfish fisheries. Such a scenario would require that the IPHC make a corresponding reduction of 5,000-8,000 mt in halibut catches by the directed fishery, or 10-20 percent of the 2002 level. Thus, even with removal of bycatch restrictions, IPHC would limit total removals of halibut to a level that would protect the resource to avoid adverse impacts to stock status.

Under FMP 2.2, halibut PSC caps would be retained. As a result, there would be no increased halibut mortality above current levels, and no adjustment to the halibut harvest quota by IPHC would be necessary.

FMP 2.1 – Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 2.1 is shown in Table 4.5-31, and a summary of the ratings for all effects is provided in Table 4.6-2. For further information on persistent past effects included in this analysis see Section 3.5.2.1 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA Pacific halibut is insignificant under FMP 2.1 because current management of halibut by IPHC accounts for all removals of halibut including bycatch in other fisheries when setting quotas for the directed fishery. Thus, if changes to the baseline condition of the stock occur, quotas set by the IPHC for the directed fishery will be adjusted accordingly.

- **Persistent Past Effects.** No persistent past effects of mortality on Pacific halibut have been identified. It is inferred that halibut bycatch in the past fisheries was accounted for under the IPHC management process that is still in effect today.

- **Reasonably Foreseeable Future External Effects.** The directed longline fishery for Pacific halibut remains in effect, but is closely managed by IPHC. Although state-managed fisheries may incidentally catch halibut, IPHC provides for all removals, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, changes in halibut bycatch (increase or decrease) are reflected in changes to quotas set for the directed fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in halibut mortality. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** The combined effects of mortality on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effect of changes in reproductive success on BSAI and GOA Pacific halibut is insignificant under FMP 2.1. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. No significant change from the baseline condition is expected as a result of FMP 2.1.

- **Persistent Past Effects.** No persistent past effects of changes in reproductive success on Pacific halibut have been identified. Currently, halibut stocks are considered healthy and stable.

- **Reasonably Foreseeable Future External Effects.** Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in reproductive success for halibut, since there is no significant spatial/temporal overlap between these fisheries and halibut spawning areas. Long-term climate change and regime shifts could have impacts to the reproductive success of Pacific halibut depending on the direction of the shift. It has

been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in reproductive success on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.1.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effect of changes in prey availability on BSAI and GOA Pacific halibut is insignificant under FMP 2.1. Halibut are opportunistic predators with a wide range of prey species and no significant change to prey structure is expected as a result of FMP 2.1.

- **Persistent Past Effects.** No persistent past effects impacting prey availability of halibut have been identified.

- **Reasonably Foreseeable Future External Effects.** Increase in prey competition between Pacific halibut and fisheries catch is not expected. Thus, the directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in prey availability for halibut. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on the prey structure of halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in prey availability on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.1.

FMP 2.2 – Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 2.2 is shown in Table 4.5-31, and a summary of the ratings for all effects is provided in Table 4.6-2. For further information on persistent past effects included in this analysis see Section 3.5.2.1.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA Pacific halibut is insignificant under FMP 2.2 because current management of halibut by IPHC accounts for all removals of halibut including bycatch in other fisheries when setting quotas for the directed fishery. Thus, if changes to the baseline condition of the stock occur, quotas set by the IPHC for the directed fishery will be adjusted accordingly.

- **Persistent Past Effects.** No persistent past effects of mortality on Pacific halibut have been identified. It is inferred that halibut bycatch in the past fisheries was accounted for under the IPHC management process that is still in effect today.

- **Reasonably Foreseeable Future External Effects.** The directed longline fishery for Pacific halibut remains in effect, but is closely managed by IPHC. Although state-managed fisheries may incidentally catch halibut, IPHC provides for all removals, including bycatch in other fisheries, when setting quotas for the directed longline fishery. Thus, changes in halibut bycatch (increase or decrease) are reflected in changes to quotas set for the directed fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in halibut mortality. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** The combined effects of mortality on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.2.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effect of changes in reproductive success on BSAI and GOA Pacific halibut is insignificant under FMP 2.2. Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. No significant change from the baseline condition is expected as a result of FMP 2.2.

- **Persistent Past Effects.** No persistent past effects of changes in reproductive success on Pacific halibut have been identified. Currently, halibut stocks are considered healthy and stable.

- **Reasonably Foreseeable Future External Effects.** Halibut spawn in deep waters of the continental slope in midwinter where they are not significantly affected by any fishery. The directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in reproductive success for halibut, since there is no significant spatial/temporal overlap between these fisheries and halibut spawning areas. Long-term climate change and regime shifts could have impacts on the reproductive success of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in reproductive success on Pacific halibut resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.2.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effect of changes in prey availability on BSAI and GOA Pacific halibut is insignificant under FMP 2.2. No significant change to prey structure is expected as a result of FMP 2.2.

- **Persistent Past Effects.** No persistent past effects impacting prey availability of halibut have been identified.

- **Reasonably Foreseeable Future External Effects.** Increase in prey competition between Pacific halibut and fisheries catch is not expected. Thus, the directed longline fishery and other state-managed fisheries are not considered contributing factors to changes in prey availability for halibut. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific halibut depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on the prey structure of halibut cannot be determined at this time.

- **Cumulative Effects.** The combined effects of changes in prey availability on Pacific halibut resulting from direct catch, internal bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.2.

4.6.2.2 Pacific Salmon or Steelhead Trout

Pacific salmon are managed by the ADF&G, which also manages the salmon sport fisheries and permitted subsistence harvesting, to ensure that escapement goals are met for the spawning population in order to maintain sustained yields from the stock as a whole. Annual harvest levels are responsive to fluctuations in run sizes. Section 4.5.2.2 provides a detailed summary of current harvest rates and stock status for salmon in Alaska.

ESA-listed Pacific Northwest chinook salmon and steelhead trout were not specifically considered in this cumulative effects analysis as discussed in Section 4.5.2.2, which also presents a summary of assumptions included in the impact analysis of the FMPs.

The cumulative effects analyses were based on two groupings of Alaska salmon in BSAI and GOA: chinook salmon and other salmon. Refer to Section 4.5.2.2 for a list of the assumptions used during the cumulative effects analysis.

FMP 2.1 and FMP 2.2 – Direct/Indirect Effects

Direct and indirect effects for chinook salmon and other salmon in BSAI and GOA include mortality along with changes in prey availability, genetic structure of population, and reproductive success.

<u>BSAI – Chinook Salmon</u>

Under FMP 2.1, chinook salmon bycatch in BSAI varies from approximately 89,000 fish in 2003 down to 51,000 fish in 2007. Assuming 58 to 70 percent of BSAI chinook salmon bycatch may be of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 30,000 to 62,000 fish during the next six years. This harvest represents approximately 10 to 20 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. Under FMP 2.1, chinook salmon bycatch would increase by 17,000 to 44,000 fish. These catch levels represent a significant increase in bycatch (>25 percent increase) and may be detectable in natal streams. This increase may impact subsistence harvests and escapement, especially in years of poor runs such as the year 2000. The bycatch levels predicted under FMP 2.1 could have conditionally significant adverse impacts on the sustainability of individual runs and on the stock as a whole. If combined with increased harvests in the GOA under FMP 2.1, the increased chinook salmon catch would be 25,000 to 50,000 fish for a total catch of 46,000 to 84,000 fish. Such catch levels would be detectable, likely impact subsistence and commercial

harvest or escapement, and have a conditionally significant adverse impact on the sustainability of individual runs or the stock as a whole.

Under FMP 2.2, chinook salmon bycatch in the BSAI varies from approximately 38,000 fish in 2003 to 24,000 fish in 2006. Assuming 58 to 70 percent of BSAI chinook salmon bycatch may be of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 14,000 to 27,000 fish during the next six years. This harvest represents approximately 4.7 to 9.0 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. This level of bycatch represents an increase of 1,000 to 9,000 fish, which may be considered significant in some years (greater than [>]25 percent). However, considering this increase across all chinook salmon runs in western Alaska, it is not likely to be detectable in natal streams, nor would it impact subsistence or commercial fisheries and escapement. If combined with increased harvests in GOA, this increase in BSAI catch could adversely impact population sustainability, especially in years of poor runs such as those seen in 2000. Therefore, the effects of mortality on BSAI chinook under FMP 2.2 are considered conditionally significant adverse.

BSAI – Other Salmon

Under FMP 2.1, bycatch of other salmon in BSAI varies from approximately 153,000 fish in 2003 down to a low of 82,000 fish in 2006. Assuming 96 percent of other salmon bycatch is chum salmon and 19 percent may be of western Alaska origin, the bycatch of western Alaska chum salmon stocks could range from 16,000 to 29,000 fish during the next six years. This harvest represents approximately 1.5 to 2.6 percent of the average western Alaska commercial and subsistence harvest of approximately 1,100,000 chum salmon from 1998 through 2000. Chum salmon bycatch would increase by 5,000 to 16,000 fish. Such bycatch levels represent a significant increase in harvest (> 25 percent increase), but would likely not be detectable in natal streams and would have little or no effect on subsistence or commercial harvests and escapement. When considered across all chum salmon stocks in western Alaska, this level of bycatch is not likely to significantly impact sustainability of any particular run or the stock as a whole. However, if combined with increased harvests in the GOA under FMP 2.1, chum salmon catches would increase by 11,000 to 24,000 fish. Such an increase could adversely impact population sustainability, especially in years of poor runs such as those in 2000. Therefore, the effects of mortality on BSAI other salmon under FMP 2.1 are considered conditionally significant adverse.

Under FMP 2.2 bycatch of other salmon in the BSAI varies from approximately 108,000 fish in 2003 to a low of 68,000 fish in 2006. Assuming 96 percent of this other salmon bycatch may be chum salmon and 19 percent may be of western Alaska origin, the bycatch of western Alaska chum salmon stocks could range from 13,000 to 21,000 fish during the next six years This harvest represents approximately 1.2 to 1.9 percent of the average western Alaska commercial and subsistence harvest of approximately 1,100,000 chum salmon from 1998 through 2000. This represents a moderate (10 to 25 percent) to significant (> 25 percent) increase in the bycatch of 2,000 to 9,000 western Alaska chum salmon. When spread across all chum salmon runs in western Alaska, such increases are not detectable in natal streams, would not significantly impact commercial or subsistence harvests or escapement. However, such an increase could have adverse impacts to population sustainability, especially in years of poor runs such as those seen in 2000. Therefore, the effects of mortality on BSAI other salmon under FMP 2.2 are considered conditionally significant adverse.

GOA – Chinook Salmon

Under FMP 2.1, chinook salmon bycatch in GOA varies from approximately 27,000 individuals in 2003 to 38,000 individuals in 2008. Assuming 58 percent of GOA chinook salmon bycatch may be of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 16,000 to 22,000 fish during the next six years. This harvest represents approximately 5.3 to 7.3 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. Chinook salmon bycatch would increase by 6,000 to 8,000 fish. Such catch levels represent a significant increase in bycatch (>25 percent increase). When spread across all the chinook salmon runs of western Alaska, this level of bycatch is not expected to be detectable in natal streams, impact subsistence harvests and escapement, or significantly impact the sustainability of the stock as a whole. However, if combined with increased bycatch in the BSAI under FMP 2.1, the increased chinook salmon catch would be 25,000 to 50,000 fish for a total catch of 46,000 to 84,000 fish. Such catch levels would be detectable, likely impact subsistence and commercial harvest and escapement, and may have a conditionally significant adverse impact on the sustainability of individual runs or the stock as a whole.

Under FMP 2.2, chinook salmon bycatch in the GOA varies from approximately 11,000 fish in 2003 up to 23,000 fish in 2008. Assuming 58 percent of GOA chinook salmon bycatch may be of western Alaska origin, the bycatch of western Alaska chinook salmon stocks could range from 6,000 to 13,000 fish during the next six years. This harvest represents approximately 2 to 4 percent of the average western Alaska commercial and subsistence harvest of approximately 300,000 chinook salmon from 1998 through 2000. Such levels of bycatch are not expected to have a significant impact on the sustainability of the stock. Considering this increase across all chinook salmon runs in western Alaska, it is not likely to be detectable in natal streams, nor would it impact subsistence or commercial fisheries and escapement. However, if combined with increased harvests in BSAI, this increase in GOA bycatch could adversely impact population sustainability, especially in years of poor runs such as those seen in 2000. Therefore, the effects on mortality of GOA chinook salmon under FMP 2.2 are considered conditionally significant adverse.

GOA – Other Salmon

Under FMP 2.1, bycatch of other salmon in the GOA varies from approximately 10,000 fish in 2003 to 13,000 fish in 2008. Assuming 56 percent of this other salmon bycatch is chum salmon, the bycatch could range from 6,000 to 7,000 fish during the next six years. The proportion of these fish from western Alaska is unknown. Assuming that all of these fish were from western Alaska, this harvest represents approximately 0.5 to 0.6 percent of the average western Alaska commercial and subsistence harvest of approximately 900,000 chum salmon from 1998 through 2000. In most cases, such bycatch levels represent a minor to moderate increase in harvest (10 to 25 percent), although in some cases, there may be significant increases in harvest (>25 percent). When considered across all chum salmon runs in western Alaska, such an increase would not be detectable in natal streams and would have no detectable effect on subsistence or commercial harvests and escapement. However, this increase in catch could have a conditionally significant adverse impact to population sustainability, if combined with increased bycatch in BSAI during years of poor runs such as those seen in 2000. Therefore, the effects of mortality on GOA other salmon under FMP 2.1 are considered conditionally significant adverse.

Under FMP 2.2, bycatch of other salmon in the GOA varies from approximately 4,000 fish in 2003 up to 9,000 fish in 2008. Assuming 56 percent of this other salmon bycatch is chum salmon, the bycatch could range from 2,000 to 5,000 fish during the next six years. The proportion of these fish from western Alaska

is unknown. Assuming that all of these fish originate in western Alaska, this harvest represents approximately 0.2 to 0.5 percent of the average western Alaska commercial and subsistence harvest of approximately 1,100,000 chum salmon from 1998 through 2000. When spread across all chum salmon runs in western Alaska, these bycatch levels are not detectable in natal streams, would have no detectable impact on subsistence or commercial catches and escapement, and are not expected to significantly impact sustainability of the stock. Therefore, the effects of mortality on GOA other salmon under FMP 2.2 are considered insignificant.

FMP 2.1 – Cumulative Effects Analysis

Summaries of the cumulative effects analysis for chinook and other salmon associated with FMP 2.1 is shown in Tables 4.5-32 and 4.5-33. A summary of the ratings for all effects is provided in Table 4.6-2. For further information on persistent past effects included in this analysis see Section 3.5.2.2.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA chinook and other salmon is considered conditionally significant adverse based on the predicted increases in catch under FMP 2.1. Such increases in bycatch levels would be detectable, likely impact subsistence and commercial harvest and escapement, and may have a conditionally significant adverse impact on the sustainability of the already depressed individual runs or the stock as a whole.

- **Persistent Past Effects.** Past foreign fisheries in Japan and Russia are associated with direct catch and bycatch of salmon in BSAI and GOA. U.S. bilateral agreements with these countries attempted to reduce gear conflicts between State of Alaska salmon fisheries and foreign fisheries while allocating salmon resources to the state fisheries. These bilateral agreements were considered marginal management measures for protection of salmon stocks. Before 1959, salmon fisheries in Alaska were managed federally. The state took over salmon management after statehood in 1959. However, the domestic fleet continued to grow during the following years and by the 1970s, the state initiated a limited entry system upon the realization that salmon stocks were being overfished. Persistent past effects of mortality on Alaskan salmon stocks exist and are associated with past foreign, JV, and domestic groundfish fisheries.

- **Reasonably Foreseeable Future External Effects.** State commercial and subsistence fisheries exert effects on mortality of BSAI and GOA chinook and other salmon populations. The magnitude of these effects cannot be determined. However, current stock status of salmon runs in western Alaska are depressed. In considering this stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. GOA non-western chinook and salmon stocks are considered stable, but state and commercial fisheries still exert effects on mortality. Similar to western Alaska stocks, the magnitude of these effects cannot be determined. State sport fisheries are not viewed as having significant impacts to salmon stocks in the GOA and are not considered contributing factors to mortality of salmon populations as a whole. Land management practices heavily influence the condition of watersheds used by spawning salmon but are not considered contributing factors in direct mortality of salmon. State hatchery enhancement programs were initiated in GOA and have a potential beneficial contribution to effects of mortality on salmon stocks. In addition, long-term climate change and regime shift are not expected to result in direct mortality of salmon.

- **Cumulative Effects.** Given the poor stock status of salmon runs in western Alaska, the combined effects of mortality on BSAI and GOA chinook and other salmon resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered conditionally significant adverse for FMP 2.1. Combined bycatch potential in the BSAI and GOA fisheries under this FMP could impede successful recovery of depressed stocks. Even for the relatively stable GOA other salmon populations, such an increase in bycatch under FMP 2.1 would not be desirable, and is considered to have a conditionally significant adverse impact due to the uncertainty regarding loss of population sustainability.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effects of FMP 2.1 on prey availability for BSAI and GOA chinook and other salmon are unknown. A relationship between fisheries bycatch of prey and salmon prey availability has not been defined.

- **Persistent Past Effects.** It has not been determined if past effects are currently impacting prey availability for BSAI and GOA chinook and other salmon.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, a relationship between state commercial, subsistence, and (in the GOA) sport fisheries bycatch of prey and salmon prey availability has not been defined and potential effects are unknown. Land management practices are not considered contributing factors in prey availability of salmon, as it is not likely that they would impact the marine environment in which salmon forage. State hatchery enhancement programs occur in GOA, but do not include prey species of salmon. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific salmon in the BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on the prey structure of salmon cannot be determined at this time.

- **Cumulative Effects.** The combined effects of potential changes in prey availability for BSAI and GOA chinook and other salmon resulting from direct catch, internal bycatch, and reasonably foreseeable future external events (both human controlled and natural) are unknown under FMP 2.1.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of FMP 2.1 on genetic structure of salmon populations in BSAI and GOA are unknown.

- **Persistent Past Effects.** It has not been determined if past effects may be impacting the genetic structure of the BSAI and GOA chinook and other salmon populations.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, salmon bycatch composition has not been determined. Potential effects of state commercial and subsistence fisheries, along with sport fisheries in the GOA, on genetic structure of salmon populations are unknown. Land management practices and long-term climate changes and regime shifts are not considered contributing factors to changes in GOA salmon populations. In the GOA, state hatchery enhancement programs focus on building certain salmon stocks, but because actual stock composition for all

species of salmon is unknown, the potential effects of this program on genetic structure of salmon populations in GOA are not known.

- **Cumulative Effects.** Due to the uncertainty of current stock composition for chinook and other salmon in the BSAI and GOA, the combined effects of changes in genetic structure on salmon populations in Alaska resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) are unknown under FMP 2.1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of FMP 2.1 on reproductive success for BSAI and GOA chinook and BSAI other salmon are considered conditionally significant adverse since stock status in this region is currently depressed and catch prediction under this FMP would increase significantly. For GOA other salmon stocks, the effects of FMP 2.1 are unknown.

- **Persistent Past Effects.** Given the poor stock status of salmon runs in western Alaska, it may be inferred that reproductive success has been impacted in certain populations. Successful reproduction of salmon depends on spawning adults' ability to reach destined spawning habitat. Persistent past effects of mortality on salmon stocks exist, and it is likely that reproductive success of these stocks has suffered as a result. Other past effects tied to freshwater life stages of salmon may also play a role in the reproductive success of certain salmon populations. Non-western Alaska chinook and other salmon stocks in the GOA are currently considered stable, so it is inferred that any past effects on the population have been mitigated over time.

- **Reasonably Foreseeable Future External Effects.** State commercial and subsistence fisheries catch of western Alaska chinook and other salmon populations could cause potential adverse impacts to reproductive success of these already depressed stocks. Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. The direct take of these fish would prevent their return to spawning grounds. In considering this depressed stock condition, impacts of increased catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. Non-western chinook and other salmon stocks in GOA are considered stable, so potential effects of state commercial, subsistence, and sport fisheries on reproductive success of these stocks are considered insignificant. Degradation of watersheds used by spawning salmon resulting from poor land management practices could significantly impact the reproductive success of BSAI and GOA salmon stocks. Thus, these practices are considered potentially adverse contributors to possible changes in reproductive success of this population. Hatchery enhancement programs in GOA may help to restore depressed stocks and maintain stable stocks in Alaska, and are considered potentially beneficial to the reproductive success of salmon.

Long-term climate change and regime shifts could have impacts on the reproductive success of Pacific salmon in BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on reproductive success of BSAI and GOA salmon cannot be determined at this time.

- **Cumulative Effects.** Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. Given the poor stock status of salmon runs in western Alaska and combined bycatch potential in the BSAI and GOA fisheries, the sustainability of BSAI and GOA chinook and BSAI other salmon stocks could be impacted. Thus, increased catch predicted under FMP 2.1 may remove spawning adults destined for spawning grounds, and potential combined effects from internal and external events are considered conditionally significant adverse to the reproductive success of BSAI and GOA chinook and BSAI other salmon. Although current stock status of GOA other salmon is stable, combined effects of changes in reproductive success in Alaskan salmon populations resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) cannot be determined for GOA other salmon stocks under FMP 2.1.

FMP 2.2 – Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 2.2 is shown in Tables 4.5-32 and 4.5-33. A summary of significance ratings for all effects is provided in Table 4.6-2. For further information on persistent past effects included in this analysis see Section 3.5.2.2.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI chinook and other salmon is considered conditionally significant adverse based on the predicted increases in catch under FMP 2.2. When spread across all chum salmon runs in western Alaska, such increases in bycatch are not detectable in natal streams, and would not significantly impact commercial or subsistence harvests or escapement. However, such an increase could have adverse impacts to population sustainability, especially in years of poor runs. Therefore, the FMP 2.2 is found to have a conditionally significant adverse effect on BSAI salmon mortality. The levels of bycatch predicted for GOA salmon are not expected to have a significant impact on the sustainability of the stock. Therefore, FMP 2.2 is found to have an insignificant effect on mortality of GOA salmon.

- **Persistent Past Effects.** Past foreign fisheries in Japan and Russia are associated with direct catch and bycatch of salmon in BSAI and GOA. U.S. bilateral agreements with these countries attempted to reduce gear conflicts between State of Alaska salmon fisheries and foreign fisheries while allocating salmon resources to the state fisheries. These bilateral agreements were considered marginal management measures for protection of salmon stocks. Before 1959, salmon fisheries in Alaska were managed federally. The state took over salmon management after statehood in 1959. However, the domestic fleet continued to grow during the following years and by the 1970s, the state initiated a limited entry system upon the realization that salmon stocks were being overfished. Persistent past effects of mortality on Alaskan salmon stocks exist and are associated with past foreign, JV, and domestic groundfish fisheries.

- **Reasonably Foreseeable Future External Effects.** State commercial and subsistence fisheries exert effects on mortality of chinook and other salmon populations. The magnitude of these effects cannot be determined, however, current stock status of salmon runs in western Alaska are depressed. In considering this stock condition, impacts of catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potential adverse contribution to the population as a whole. The GOA other salmon stocks are considered stable, thus the predicted catch rates under

FMP 2.2 do not show potential for impacts on stock sustainability and are considered insignificant. Land management practices heavily influence the condition of watersheds used by spawning salmon, but are not considered contributing factors in direct mortality of salmon. State hatchery enhancement programs were initiated in GOA and have a potentially beneficial contribution to effects of mortality on salmon stocks. In addition, long-term climate change and regime shift are not expected to result in direct mortality of salmon.

- **Cumulative Effects.** Given the poor stock status of salmon runs in western Alaska, the combined effects of mortality on BSAI chinook and other salmon resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are considered conditionally significant adverse for FMP 2.2. Combined bycatch potential in the BSAI fisheries under this FMP could impede successful recovery of depressed stocks in BSAI and impact sustainability of the stock as a whole. Current stock status of salmon in GOA is considered stable and combined effects of mortality on chinook and other salmon in this region resulting from direct catch, internal bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effects of FMP 2.2 on prey availability for BSAI and GOA chinook and other salmon are unknown. A relationship between fisheries bycatch of salmon prey items and salmon prey availability has not been defined.

- **Persistent Past Effects.** It has not been determined if past effects are currently impacting prey availability for BSAI and GOA chinook and other salmon.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, a relationship between state commercial, subsistence, and (in the GOA) sport fisheries bycatch of prey and salmon prey availability has not been defined and potential effects are unknown. Land management practices are not considered contributing factors in prey availability of salmon, as it is not likely that they would impact the marine environment in which salmon forage. State hatchery enhancement programs that occur in GOA do not include prey species of salmon. Long-term climate change and regime shifts could have impacts on certain prey species of Pacific salmon in both the BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on the prey structure of salmon cannot be determined at this time.

- **Cumulative Effects.** The combined effects of potential changes in prey availability for BSAI and GOA chinook and other salmon resulting from direct catch, internal bycatch, and reasonably foreseeable future external events (both human controlled and natural) are unknown under FMP 2.2.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of FMP 2.2 on genetic structure of salmon populations in BSAI and GOA are unknown.

- **Persistent Past Effects.** It has not been determined if past effects may be impacting the genetic structure of the BSAI and GOA chinook and other salmon populations.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, salmon bycatch composition has not been determined, so potential effects of state commercial, subsistence, and sport fisheries on genetic structure of salmon populations are unknown. Land management practices and long-term climate changes and regime shifts are not considered contributing factors to changes in GOA salmon populations. State hatchery enhancement programs focus on building certain salmon stocks, but because actual stock composition for all species of salmon is unknown, the potential effects of this program on genetic structure of salmon populations in GOA are not known.

- **Cumulative Effects.** Due to the uncertainty of current stock composition for chinook and other salmon in BSAI and GOA, the combined effects of changes in genetic structure on salmon populations in Alaska resulting from direct catch, internal bycatch, and reasonably foreseeable future external events (both human controlled and natural) are unknown under FMP 2.2.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of FMP 2.2 on reproductive success for BSAI chinook and other salmon are considered conditionally significant adverse since stock status in this region is currently depressed and catch prediction under this FMP would increase significantly. For GOA stocks, the effects of FMP 2.2 are unknown.

- **Persistent Past Effects.** Given the poor stock status of salmon runs in western Alaska it may be inferred that reproductive success has been impacted in certain populations of BSAI region. Successful reproduction of salmon depends on spawning adults' ability to reach destined spawning habitat. Persistent past effects of mortality on salmon stocks exist, and it is likely that reproductive success of these stocks has suffered as a result. Other past effects tied to freshwater life stages of salmon may also play a role in the reproductive success of certain salmon populations. Stocks in GOA are currently considered stable so it is inferred that any past effects on the population have been mitigated over time.

- **Reasonably Foreseeable Future External Effects.** State commercial and subsistence fisheries catch of western chinook and other salmon populations could cause potential adverse impacts to reproductive success of these already depressed stocks. Alaska chinook and other salmon stocks in GOA are considered stable, so potential effects of state commercial, subsistence, and sport fisheries on reproductive success of these stocks are considered insignificant. Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. The direct take of these fish would prevent their return to spawning grounds. In considering this depressed stock condition, impacts of increased catch and bycatch by state fisheries could hinder recovery of depressed stocks and are considered a potentially adverse contribution to the population as a whole. Degradation of watersheds used by spawning salmon resulting from poor land management practices could significantly impact the reproductive success of BSAI salmon stocks. Thus, these practices are considered potentially adverse contributions to possible changes in reproductive success of this population. Hatchery enhancement programs in GOA may help to restore depressed stocks and maintain stable stocks in Alaska and are considered potentially beneficial to the reproductive success of salmon. Long-term climate change and regime shifts could have impacts on the reproductive

success of Pacific salmon in BSAI and GOA depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species. However, the effects of this type of large scale event on reproductive success of BSAI and GOA salmon cannot be determined at this time.

- **Cumulative Effects.** Successful reproduction of salmon relies on spawning adults' ability to reach destined spawning habitat. Given the poor stock status of salmon runs in western Alaska and combined bycatch potential in the BSAI fisheries, the sustainability of BSAI chinook and other salmon stocks could be impacted. Thus, increased catch predicted under FMP 2.2 may remove spawning adults destined for spawning grounds and potential combined effects from internal and external events is considered conditionally significant adverse to the reproductive success of BSAI salmon. Although current stock status of GOA chinook and other salmon is stable, combined effects of changes in reproductive success in Alaskan salmon populations resulting from direct catch, bycatch, and reasonably foreseeable future external events (both human controlled and natural) cannot be determined for GOA stocks under FMP 2.2.

4.6.2.3 Pacific Herring

Pacific herring are managed by the ADF&G. Harvest policy and allocations among gear (user) groups is established by the Alaska Board of Fisheries. Annual harvest quotas are set by ADF&G under an exploitation rate harvest policy; herring exploitation rates are capped at a maximum level of 20 percent statewide. All directed herring fisheries occur in state waters and are managed by regulatory stocks.

A detailed discussion of the modeling approach used in this analysis is included in Section 4.5.2.3. Given the low herring bycatch levels that are predicted across all FMPs, bycatch removals would not be expected to have significantly different impacts on herring abundance estimates among FMPs.

FMP 2.1 and FMP 2.2 – Direct/Indirect Effects

Direct and indirect effects for Pacific herring include mortality, along with changes in reproductive success, prey availability, and habitat. These effects, which are associated with changes in catch, are considered insignificant for the following reasons: bycatch of herring in the groundfish fisheries is generally low, the fisheries do not target herring prey, and spatial/temporal overlap between the groundfish fisheries and herring habitat is minimal. In addition, annual quota setting processes implemented by ADF&G are responsive to fluctuations in herring biomass.

FMP 2.1 and FMP 2.2 – Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with FMP 2 is shown in Table 4.5-34. For further information on persistent past effects included in this analysis see Section 3.5.2.3 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA herring is insignificant under FMP 2.1 and FMP 2.2 because even with the opening of the Herring Savings Areas, current management of herring by ADF&G is responsive to fluctuations in herring biomass. The herring savings areas reduce herring bycatch potential by triggering closures in years when

herring are abundant within fishing grounds. Although FMP 2.1 would remove the herring savings areas, it is presumed that the intensive harvest management currently in place with ADF&G would account for any increases in catch or respond accordingly to changes in biomass.

- **Persistent Past Effects.** Domestic herring fisheries became prominent in the early 1900s with peak catches occurring in the 1920s and 1930s. Foreign herring harvests became prominent in the BSAI in the late 1950s, with highs in the late 1960s and early 1970s. Overexploitation of herring likely resulted during these years of high catch. By 1980, foreign harvest of herring had been eliminated; however, years of unregulated catch of herring may have impacted herring populations over the long-term. In addition, past federal groundfish fisheries bycatch combined with the directed state fisheries have exceeded the state's herring harvest policy in the past and may still exert lingering effects on current herring populations in the BSAI and GOA.

- **Reasonably Foreseeable Future External Effects.** Directed state herring fisheries still occur, but are closely managed by the state (ADF&G). Fishing quotas are based on variable exploitation rates that account for declines in stock and are capped at a maximum rate of 20 percent. State subsistence catch does not constitute a significant amount of catch compared to the directed fishery and is accounted for in ADF&G herring management plans. These fisheries are not considered contributing factors to changes in herring mortality. Future acute and chronic marine pollution could occur and is considered potentially adverse to herring mortality, especially for those populations that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts are not considered contributing factors as they are not expected to result in direct mortality.

- **Cumulative Effects.** ADF&G Pacific herring management plans are responsive to changes in herring biomass and fishing quotas are based on variable exploitation rates that account for declines in stock and are capped at a maximum rate of 20 percent. Thus, although some persistent past effects may still be present on certain herring populations in the BSAI and GOA, the combined effects of mortality on Pacific herring resulting from direct catch, internal bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.1 and FMP 2.2.

<u>Change in Reproductive Success</u>

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on reproductive success of BSAI and GOA herring is insignificant under FMP 2.1 and FMP 2.2, due to the low amounts of estimated herring bycatch, and because current management of herring by ADF&G is responsive to fluctuations in herring biomass. Thus, if a change in reproductive success occurs, it would most likely be reflected in corresponding changes to biomass, which are incorporated into ADF&G management plans of Pacific herring.

- **Persistent Past Effects.** As discussed in the analysis of cumulative effects on Pacific herring mortality, past federal groundfish fisheries bycatch combined with the directed state fisheries have exceeded the state's herring harvest policy in the past and may still exert lingering effects on current herring populations in the BSAI and GOA. Herring spawning habitat in the GOA (specifically PWS) was contaminated with oil resulting from the EVOS in 1989. It has been found that this type of contamination exposure to adult and larval herring can result in many adverse effects such as: increased rates of egg mortality, larval deformities, and immune system deficiencies. It is presumed

that the effects of EVOS still exist and subsets of herring populations in the GOA are still recovering.

- **Reasonably Foreseeable Future External Effects.** Directed state herring fisheries still occur but are closely managed by the state (ADF&G). Fishing quotas are based on variable exploitation rates that account for declines in stock. State subsistence fisheries catch are also accounted for in ADF&G herring management plans. Thus, these fisheries are not considered contributing factors to changes in herring reproductive success. Future acute and chronic marine pollution could occur and is considered potentially adverse to herring reproductive success, especially for those populations that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts could have impacts to the reproductive success of Pacific herring depending on the direction of the shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on herring cannot be determined at this time.

- **Cumulative Effects.** ADF&G Pacific herring management plans are responsive to changes in herring biomass, and fishing quotas are based on variable exploitation rates that account for declines in stock. Although certain herring populations in the GOA have been impacted by EVOS, the stock as a whole is considered recovering. Thus, some persistent past effects may still be present on certain herring populations in the BSAI and GOA, but the combined effects on Pacific herring reproductive success resulting from direct catch, internal bycatch, and reasonably foreseeable future external events (both human controlled and natural) are considered insignificant for FMP 2.1 and FMP 2.2.

Change in Prey Availability

- **Direct/Indirect Effects.** The potential effect of Federal groundfish fisheries on prey availability for BSAI and GOA herring is insignificant under FMP 2.1 and FMP 2.2, because groundfish fisheries do not target herring prey and if current management by ADF&G is responsive to fluctuations in herring biomass regardless of the cause associated with the change. Thus, if a change in prey availability did occur, it would most likely be reflected in corresponding changes to biomass, which are accounted for in ADF&G management plans of Pacific herring.

- **Persistent Past Effects.** No persistent past effects impacting prey availability of herring have been identified.

- **Reasonably Foreseeable Future External Effects.** Pacific herring prey primarily on zooplankton which is not affected by state directed herring fisheries or state subsistence fisheries. Thus, these fisheries are not considered contributing factors to changes in prey availability for herring. Future acute and chronic marine pollution could occur, but effects on prey such as zooplankton are unknown. Long-term climate change and regime shifts could have impacts to many species that contribute to the prey structure of Pacific herring. The nature of these impacts depends on the direction of the climatic shift. It has been shown that warm trends favor recruitment while cool trends weaken recruitment in most fish species; however, the effects of this type of large scale event on herring cannot be determined at this time.

- **Cumulative Effects.** Potential effects of future natural events, such as marine pollution and climatic shifts, on prey availability for Pacific herring are unknown for FMP 2.1 and FMP 2.2.

Change in Habitat

- **Direct/Indirect Effects.** The potential effect of federal groundfish fisheries on habitat of BSAI and GOA herring is insignificant under FMP 2.1 and FMP 2.2, because current management of herring by ADF&G is responsive to fluctuations in herring biomass and spatial/temporal overlap between the fisheries and herring habitat is minimal. However, if a change in important habitat were to occur, it would most likely be reflected in corresponding changes to biomass, which are accounted for in ADF&G management plans of Pacific herring. In FMP 2.2, the herring savings areas would reduce herring bycatch potential and protect important habitat by triggering closures in years when herring are abundant within fishing grounds. Despite the removal of these areas under FMP 2.1, it is presumed that any significant changes to biomass would be accounted for in the harvest management plans set forth by ADF&G.

- **Persistent Past Effects.** Herring spawning habitat in the GOA (specifically PWS) was contaminated with oil resulting from the EVOS in 1989. The long-term effects of this event to herring habitat are unknown. It is presumed that the effects of EVOS still exist and subsets of herring populations in the GOA are still recovering.

- **Reasonably Foreseeable Future External Effects.** No evidence of fishery impact on habitat of herring exists. Thus, fisheries are not considered contributing factors to changes in herring habitat at this time. Future acute and chronic marine pollution could occur and is considered potentially adverse to some herring habitat, especially those that are still recovering from EVOS in the GOA. Long-term climate change and regime shifts are not expected to significantly change physical habitat of Pacific herring.

- **Cumulative Effects.** Potential impacts of future natural events, such as marine pollution and climatic shifts, in addition to lingering contamination from EVOS on certain habitat of herring in the GOA exist, but effects are not known for FMP 2.1 and FMP 2.2.

4.6.2.4 Crab

Alaska king, bairdi Tanner crab, and opilio Tanner crab (also called snow crab) fisheries are managed by the State of Alaska, with Federal oversight and following guidelines established in the BSAI king and Tanner crab FMP (NPFMC 1989). Section 4.5.2.4 contains further information on current stock status and management of crab in Alaska.

For the cumulative effects analysis, crab stocks in BSAI and GOA will be placed in the following groups: Bairdi Tanner, Opilio Tanner (only BSAI), Red king, Blue king, and Golden king. Opilio Tanner crab populations are not encountered during ADF&G surveys in the GOA. It is inferred that this crab species is not prevalent in this region. Therefore, GOA opilio Tanner crab is not included in this analysis.

Direct/Indirect Effects FMP 2.1 and FMP 2.2

Direct and indirect effects for all species of crab in BSAI and GOA include mortality along with changes in biomass, reproductive success, prey availability, and habitat. These effects may be attributed to fishing activities (both directed and undirected), but may also be linked to natural events such as long-term climatic change and decadal regime shifts. Significance of these effects is based on the likelihood that population-

level changes will result from internal events within the groundfish fishery. An effect that is considered insignificant corresponds to a change that is not likely to result in population-level effects on crab or that lies within the range of natural variability for the species. Significance ratings for the individual direct and indirect effects are discussed in the following cumulative effects sections.

Cumulative Effects Analysis FMP 2.1

Summaries of the cumulative effects analyses associated with FMP 2.1 are shown in Tables 4.5-36 through 4.5-42. Table 4.6-2 provides a summary of the significance ratings for all effects on crab. For further information on persistent past effects included in this analysis see Section 3.5.2.4 of this Programmatic SEIS.

The foundation of the cumulative effects analysis is the baseline description for each species that includes population status and trends, if known, and the major human and natural influences that have affected the population in the past and that continue to the present.

For each species, the predicted direct and indirect effects of the groundfish fishery are then analyzed for their contribution to the overall impacts from all sources, including reasonably foreseeable future events resulting from human and natural events external to the fishery. The reasonably foreseeable future events include other U.S. and foreign fisheries, acute and chronic environmental pollution, and natural events such as climatic and oceanographic fluctuations. Cumulative effects are rated according to the same significance criteria as the direct/indirect effects of the fishery and are based on the potential for population-level effects.

Mortality

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Under FMP 2.1, predicted catch of these crab species increases significantly from the current baseline condition, although catch trends do fluctuate throughout the five-year period. Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. Increases in crab catch and bycatch by federal fisheries, in addition to removal of protection areas, trawl closures, and PSC limits proposed under this FMP, could significantly impact sustainability and recovery of these already depressed stocks. Thus, FMP 2.1 is rated as significantly adverse to bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI considering that no signs of recovery have been evident for these stocks to date.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab

fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and are managed by ADF&G in cooperation with NOAA Fisheries. These fisheries are considered to have a potentially adverse effect on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI, since no signs of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock also has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect but the population is currently considered depressed. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on crab populations in the BSAI still exist and stocks are considered depressed, and in some instances overfished, with no signs of recovery to date. Thus, these combined effects of mortality, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events, are considered significantly adverse to bairdi Tanner, opilio Tanner, red king, and blue king crab populations in BSAI under FMP 2.1.These effects could further impede the recovery of the population, although the driving factor(s) behind the BSAI crab stocks' lack of recovery have not been determined.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Under FMP 2.1, predicted catch rates of golden king crab in BSAI and GOA were combined with those for blue king crab. The BSAI predictions showed slight increases in catch over the next five years when compared to current catch rates. Model projections for GOA catch showed minor decreases in catch compared to current catch in this region. However, significance of these predicted changes in catch on mortality is unknown due to lack of survey information for determining current stock status. Thus, effects of FMP 2.1 on mortality of BSAI and GOA golden king crab are unknown.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in BSAI and GOA are currently unknown. Thus, the potential effects of these fisheries on mortality are not known. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on golden king crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed, but the overall stock status of golden king crab in BSAI and GOA is unknown. Potential increases in crab bycatch and catch, in addition to removal of protection areas, trawl closures, and PSC limits proposed under FMP 2.1, could have significant impacts on the sustainability of these stocks. However, potential combined effects of mortality, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined due to lack of a current baseline condition.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Under FMP 2.1, predicted catch of bairdi Tanner, red king, and blue king crab in GOA showed large increases from current catch levels over the next five years. However, significance of these predicted changes in catch on mortality is unknown. Some stocks of bairdi Tanner crab in GOA show signs of possible recovery while others are still considered depressed. Under FMP 2.1, potential for catch increases and removal of protection areas and trawl closures are proposed. This could have conditionally significant adverse effects on these stocks should lack of recovery continue. GOA red king stocks are severely depressed according to ADF&G survey data and do not show signs of recovery. For the same reasons mentioned above for bairdi Tanner crab, FMP 2.1 is rated as significantly adverse to red king crab stocks. Blue king crab stock status in GOA has not been determined by ADF&G, but it is presumed that these stocks may also be depressed. However, the effects of FMP 2.1 on mortality of blue king crab populations in GOA are unknown, until a baseline condition can be established.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in bottom trawl fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of external fisheries on mortality of bairdi Tanner and blue king crab stocks are not known. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in

addition to external mortality associated with state fisheries (directed, subsistence, and scallop), could adversely impact recovery and sustainability of red king crab stocks in GOA. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed, but their overall stock status is unknown. Thus, potential combined effects of mortality, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined for bairdi Tanner and blue king crab stocks at this time for FMP 2.1. Under FMP 2.1, crab catch is expected to increase while protection areas and trawl closures are removed. These factors, in addition to potential effects of mortality on red king stocks in the GOA are considered significantly adverse due to the already severely depressed nature of these stocks, and the lack of recovery that has been observed.

Change in Biomass

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances, overfished. Increases in crab bycatch by federal fisheries, in addition to removal of protection areas, trawl closures, and PSC limits proposed under this FMP, could significantly impact sustainability and recovery of these already depressed stocks. Thus, FMP 2.1 is rated as significantly adverse to bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI considering that no signs of recovery have been evident for these stocks to date.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea, and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fishing effects could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. These fisheries are considered to have a potentially adverse effect on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI, since no signs

of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock also has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed. Potential effects of climate change and regime shifts on biomass levels of crab in BSAI have not been determined and depend on the direction of change that occurs.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on crab populations in the BSAI still exist and stocks are considered depressed with no signs of recovery to date. Increases in crab bycatch, in addition to removal of protection areas, trawl closures, and PSC limits proposed under FMP 2.1, could significantly impact sustainability and recovery of these stocks. Thus, these combined effects, resulting from past events, direct catch, internal bycatch, and reasonably foreseeable future external events, are considered significantly adverse to changes in biomass and sustainability of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI. These effects could further jeopardize the sustainability of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in the BSAI under FMP 2.1, although the driving factor(s) behind the BSAI crab stocks' lack of recovery have not been determined.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, potential effects of FMP 2.1 on changes to biomass cannot be determined.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries, but the composition of this catch is unknown. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. The potential effects of past fishing mortality on biomass of golden king crab stocks in BSAI and GOA cannot be determined because catch composition is unknown, and biomass estimates over time do not exist for these stocks.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in BSAI and GOA is unknown, and biomass estimates have not been determined. Thus, the potential effects of these fisheries on biomass are not known. Potential effects of long-term climate change and regime shifts on crab biomass levels have not been determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on golden king crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed, but the overall stock status of golden king crab in BSAI and GOA is unknown and biomass estimates have not been determined. Thus, potential effects on biomass of BSAI and GOA golden king crab stocks, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 2.1.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Some stocks of bairdi Tanner crab in GOA show signs of possible recovery while others are still considered depressed. Under FMP 2.1, potential for catch increases and removal of protection areas and trawl closures are proposed. This could have conditionally significant adverse effects on these stocks should lack of recovery continue. GOA red king stocks are severely depressed according to ADF&G survey data and do not show signs of recovery. For the same reasons mentioned above for bairdi Tanner crab, FMP 2.1 is rated as significantly adverse to red king crab stocks. Blue king crab stock status in GOA has not been determined by ADF&G, but it is presumed that these stocks may also be depressed. The effects of FMP 2.1 on biomass of blue king crab populations in GOA are unknown until a baseline condition can be established.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in bottom trawl fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Adverse effects of past fishing mortality on biomass of bairdi Tanner, blue king, and red king crab stocks in GOA may still exist as recovery of depressed stocks has not occurred.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to be managed by ADF&G in cooperation with NOAA Fisheries. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of these fisheries on biomass of bairdi Tanner and blue king crab stocks cannot be determined. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in addition to external mortality associated with state fisheries (directed, subsistence, and scallop), could adversely impact recovery and sustainability of red king crab stocks in GOA. Potential effects of long-term climate change and regime shifts on crab biomass levels have not been determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed, but their overall stock status is unknown. Thus, potential effects on biomass of bairdi Tanner and blue king crab in GOA, resulting from past events, internal bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 2.1. Potential effects on biomass of red king crab in GOA, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events

are considered significantly adverse due to the already severely depressed nature of these stocks, lack of signs for recovery, and potential for increases in catch and removal of protection areas under FMP 2.1.The combined effects could further impede the recovery of the population, although the driving factor(s) behind the red king crab stocks' lack of recovery have not been determined.

Change in Reproductive Success

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** These stocks are currently considered depressed and in some instances, overfished. Changes in reproductive success within BSAI crab populations may be an underlying factor in the depressed nature of these stocks. However, a direct causation between spawning-recruitment success and depressed stock status cannot be concluded at this time. Increases in crab bycatch by federal fisheries, in addition to removal of protection areas, trawl closures, and PSC limits proposed under this FMP, could significantly impact sustainability and recovery of these already depressed stocks. Therefore, the potential effects of FMP 2.1 on changes to reproductive success are considered conditionally significant adverse to these stocks.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea, and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Directed crab fishing seasons are set to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on crab populations in the BSAI may still exist, and stocks are considered depressed with no signs of recovery to date. Increases in crab bycatch by federal fisheries, in addition to removal of protection areas, trawl closures, and PSC limits proposed under this FMP, could significantly impact sustainability and recovery of these already depressed stocks. A relationship between spawning-recruitment success and other factors impeding on reproductive potential to depressed stock status cannot be drawn at this time Thus, potential effects reproductive success, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events, are considered conditionally significant adverse under FMP 2.1.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, potential effects of FMP 2.1 on changes to reproductive success cannot be determined.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries, but the composition of this catch is unknown. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Current stock status of BSAI and GOA golden king crab has not been determined, so potential past effects on reproductive success are also unknown.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Crab seasons are set as to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of golden king crab. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on golden king crab populations in the BSAI and GOA are not known. Potential effects on reproductive success, resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events are unknown for FMP 2.1 until a baseline condition is defined. It should be noted that increased mortality resulting from removal of PSC limits, bycatch restrictions, protection areas, and trawl closures as proposed under this FMP, could significantly impact the reproductive success and sustainability of these stocks.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Changes in reproductive success within GOA crab populations may be an underlying factor in the depressed nature of these stocks. Survey data collected by ADF&G for certain bairdi Tanner crab stocks in western GOA show signs of possible recovery while other GOA stocks are still considered depressed. Although, a direct causation between reproductive success and

depressed stock status cannot be concluded at this time, the potential for catch increases and removal of protection areas and trawl closures proposed under FMP 2.1, could have conditionally significant adverse effects on these stocks should lack of recovery continue. Red king crab populations in GOA are at historic lows according to ADF&G survey information. For the same reasons mentioned above for bairdi Tanner crab, FMP 2.1 is rated as conditionally significant adverse to red king crab stocks. Blue king crab stock status in GOA has not been determined by ADF&G, but it is presumed that these stocks may also be depressed. The effects of FMP 2.1 on reproductive success of blue king crab populations in GOA are unknown until a baseline condition can be established.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as some of these stocks have not shown signs of recovery to date. Current stock status of GOA blue king crab has not been determined, so potential past effects on reproductive success are also unknown.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Crab seasons are set as to avoid mating and molting periods so these fisheries are not considered contributing factors to changes in reproductive success of these stocks. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on crab populations in the GOA may still exist, and some stocks are considered depressed with no signs of recovery to date. Under FMP 2.1, there is a potential for increases in fishing mortality and removal of protection areas. This could have conditionally significant adverse effects on these stocks should lack of recovery continue. Potential effects on reproductive success of bairdi Tanner and blue king crab in GOA, resulting from past events, direct catch, internal bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 2.1 due to lack of current baseline condition. Potential effects on reproductive success of red king crab in GOA, resulting from past, present, and future events are considered conditionally significant adverse due to the already severely depressed nature of these stocks, lack of signs for recovery, and potential for increases in fishing mortality and removal of protection areas under FMP 2.1.

Change in Prey Availability

Bairdi Tanner, Opilio Tanner, Red King, Blue King, and Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Diet composition of crab has not been determined, but crab are known to be benthic feeders. Competition for prey species of crab resulting from groundfish fisheries' catch has not been shown, and it is unclear if FMP 2.1 would impact prey structure and availability for all species of crab throughout BSAI and GOA. Thus, potential effects of FMP 2.1 on changes in prey availability cannot be determined.

- **Persistent Past Effects.** Crab are benthic feeders and generally feed on invertebrates. Catch of crab prey in current and past fisheries is minimal. Thus, past effects on crab prey structure and availability in BSAI and GOA have not been identified.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Competition for prey species of crab resulting from groundfish fisheries' catch has not been shown, and these fisheries are not considered contributing factors to changes in prey availability. Rebuilding plans currently in effect in BSAI do not address crab prey structure and availability and are not considered contributing factors to potential changes in prey availability. Long-term climate change and regime shifts may impact crab prey structure depending on the direction of the change. However, it is impossible to determine the potential effects that these changes may have on crab populations throughout BSAI and GOA.

- **Cumulative Effects.** Diet composition of crab has not been determined and potential changes to prey structure, resulting from past, present, and future events, cannot be determined for all species of crab in BSAI and GOA.

Change in Habitat

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** These stocks are currently considered depressed and in some instances, overfished. However, a direct link between changes to habitat and the depressed stock status of these crab species in the BSAI cannot be concluded at this time. Numerous ADF&G management measures, rebuilding plans, trawl closures, and conservation areas have been implemented to address declining and overfished crab stocks in BSAI. Under FMP 2.1, removal of protection areas and trawl closures throughout BSAI could impede on the recovery of these stocks and significantly impact the sustainability of BSAI crab stock as a whole. Thus, FMP 2.1 is considered significantly adverse to changes in crab habitat.

- **Persistent Past Effects.** The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have directly or indirectly impacted spawning and nursery habitat as a result of trawling and using other types of fishing gear that interact with bottom habitat. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and are considered potentially adverse factors to possible changes in crab habitat based on the lack of recovery that has been observed for these stocks under current management plans. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock also has a rebuilding plan in effect. In

the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at this time. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time and offer protection of critical habitat. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed, and possible habitat-related effects have not been determined. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors.

- **Cumulative Effects.** Persistent past effects on crab habitat in the BSAI may still exist and stocks are considered depressed with no signs of recovery to date. Although some of the known habitat areas of BSAI crab are currently protected by no trawl zones and conservation zones, these protection measures would be removed under FMP 2.1. Thus, potential combined effects on BSAI crab habitat, resulting from past, present, and future events, would be considered significantly adverse to sustainability of these stocks due to the proposed removal of protection areas and trawl closures under this FMP.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, it is difficult to identify habitat-related effects as they pertain to changes in these crab populations throughout BSAI and GOA. Potential effects of FMP 2.1 to crab habitat are unknown.

- **Persistent Past Effects.** The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Current stock status of BSAI and GOA golden king crab has not been determined, so potential past effects on essential habitat are also unknown.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and are considered potentially adverse factors in possible changes to crab habitat based on the lack of recovery that has been observed for many of the crab stocks under current management plans. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors.

- **Cumulative Effects.** It is unclear if persistent past effects on golden king crab habitat in the BSAI and GOA exist. Some GOA golden king crab stocks are considered depressed, although some of the known habitat areas of BSAI and GOA crab are currently protected by no trawl zones and conservation zones. These protection measures would be removed under FMP 2.1; however, it is uncertain how these measures would affect the BSAI and GOA golden king crab stocks due to the lack of a current baseline condition. Thus, potential combined effects on BSAI and GOA golden king crab habitat, resulting from past, present, and future events cannot be determined for FMP 2.1 without first establishing the overall population status of this species. However, it should be noted that removal of protection areas and trawl closures proposed under this FMP could significantly impact the sustainability of this stock if increases in mortality and changes to reproductive success result.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Red king crab stocks are severely depressed in GOA according to ADF&G survey data. Bairdi Tanner crab stocks in the GOA are currently considered depressed while blue king crab stock status is unknown, but presumed to be depressed based on limited survey data. Although, a relationship between changes to habitat and depressed stock status cannot be drawn at this time the removal of protection areas and trawl closures throughout the GOA as proposed under FMP 2.1, could impede the recovery of these stocks and significantly impact the sustainability of GOA crab stock as a whole. Thus, this FMP is considered significantly adverse to changes in crab habitat for the already depressed red king crab stocks in GOA, and conditionally significant adverse for GOA bairdi Tanner crab stocks. This FMP could result in significantly adverse impacts to blue king crab stocks in GOA, but it is difficult to determine how these stocks will react to potential changes in habitat until a baseline condition has been established.

- **Persistent Past Effects.** The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have directly or indirectly impacted spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as some of these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and are considered potentially adverse factors in possible changes to crab habitat based on the lack of recovery that has been observed for these stocks under current management plans. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes to GOA crab habitat.

- **Cumulative Effects.** Persistent past effects on crab habitat in the GOA may still exist, and stocks are considered depressed with no signs of recovery to date. Thus, potential combined effects on GOA red king crab habitat, resulting from past, present, and future events are considered significantly adverse under FMP 2.1. Potential combined effects on GOA bairdi Tanner and blue king crab habitat cannot be determined for FMP 2.1 without first establishing the overall population status of this species. Removal of protection areas and trawl closures proposed under this FMP, could significantly impact the sustainability of these stocks if increases in mortality, and changes to reproductive success result and impede on recovery of currently depressed stocks.

Cumulative Effects Analysis FMP 2.2

Summaries of the cumulative effects analyses for crab associated with FMP 2.2 are shown in Tables 4.5-36 through 4.5-42. Table 4.6-2 provides a summary of significance ratings for all effects (direct, indirect, and cumulative). For further information on persistent past effects included in this analysis (see Section 3.5.2.4).

Mortality

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Under FMP 2.2, predicted bycatch of these crab species are slightly higher than the 2002 bycatch estimates. Blue king and red king crab bycatch are predicted to be the highest under this FMP, largely due to the spatial changes in distribution of the yellowfin sole and rock sole trawl fisheries. Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances overfished. Thus, FMP 2.2 is considered to have a conditionally significant adverse effect on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI due to the predicted increase in bycatch, and because no signs of recovery for these stocks have been shown to date.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch, and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and are considered to have potential adverse effects on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI, since no signs of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at this time. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on crab populations in the BSAI may still exist, and stocks are considered depressed with no signs of recovery to date. Thus, these combined effects of mortality resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events are considered conditionally significant adverse for FMP 2.2.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Under FMP 2.2, predicted catch of golden king crab in BSAI and GOA were combined with predictions for blue king crab. The BSAI predictions showed increases and decreases in catch over the next five years when compared to current catch rates. Model projections for GOA catch showed decreases in catch compared to current catch in this region. However, significance of these predicted changes in catch on mortality is unknown due to lack of survey information for determining current stock status. Thus, effects of FMP 2.2 on mortality of BSAI and GOA golden king crab are unknown.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI and GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in BSAI and GOA are currently unknown. Thus, the potential effects of these fisheries on mortality are not known. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on golden king crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed, but the overall stock status of golden king crab in BSAI and GOA is unknown. Thus, potential combined effects of mortality resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 2.2.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Under FMP 2.2, predicted catch of bairdi Tanner, red king, and blue king crab in GOA showed increases and decreases from current baseline for the next five years. However, significance of these predicted changes in catch on mortality is unknown due to lack of survey information for determining current stock status of bairdi Tanner and blue king crab. Thus, effects of FMP 2.2 on mortality of GOA bairdi Tanner, and blue king crab are unknown. GOA red king crab stocks are severely depressed according to ADF&G survey data and do not show signs of recovery. Although red king crab bycatch is predicted to be slightly below the 2002 level, the effects of mortality could further impede the ability of this stock to recover. Thus, effects of FMP 2.2 on mortality of GOA red king crab are considered conditionally significant adverse.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in bottom trawl fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on GOA crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of these fisheries on mortality of bairdi Tanner and blue king crab stocks are not known. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in addition to mortality associated with state fisheries (directed, subsistence, and scallop), could adversely impact recovery and sustainability of red king crab stocks in GOA. Long-term climate change and regime shifts are not expected to result in direct mortality of crab stocks and are not considered contributing factors to potential changes in crab mortality.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed, but their overall stock status is unknown. Thus, potential combined effects of mortality resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined for bairdi Tanner and blue king crab stocks at this time for FMP 2.2. Potential combined effects of mortality on red king stocks in the GOA are considered conditionally significant adverse due to the already severely depressed nature of these stocks and apparent lack of recovery.

Change in Biomass

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** Although current bycatch limits and quota-setting processes are responsive to fluctuations in stock and account for crab bycatch in other state and federal fisheries, these stocks are currently considered depressed and in some instances overfished. The predicted bycatch levels under FMP 2.2 are expected to be slightly higher than baseline estimates. The bycatch levels predicted for red and blue king crab are the highest under this FMP. Thus, FMP 2.2 is considered to have a conditionally significant adverse effect on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI because no signs of recovery for these stocks have been shown to date.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the

distribution of mature female red king crab brood stocks in the Bering Sea, and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, adverse past effects of mortality on BSAI crab stocks from directed crab catch and bycatch could still exist.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and are considered to have potential adverse effects on bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI, since no signs of recovery have been shown. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, the population is currently considered depressed. Potential effects of long-term climate change and regime shifts on biomass levels have not been determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on crab populations in the BSAI still exist and stocks are considered depressed with no signs of recovery to date. Thus, these combined effects resulting from past events, direct catch, internal bycatch, and reasonably foreseeable future external events are considered conditionally significant adverse to biomass and sustainability of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI for FMP 2.2.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, potential effects of FMP 2.2 on changes to biomass cannot be determined.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries, but the composition of this catch is unknown. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. The potential effects of past fishing mortality on biomass of golden king crab stocks in BSAI and GOA cannot be determined because catch composition is unknown, and biomass estimates over time do not exist for these stocks.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur be managed by ADF&G in cooperation with NOAA

Fisheries. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for golden king crab, but the overall stock status of golden king crab stocks in BSAI and GOA is unknown and biomass estimates have not been determined. Thus, the potential effects of these fisheries on biomass are not known. Potential effects of long-term climate change and regime shifts on biomass levels has not been determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on golden king crab populations in the BSAI and GOA may still exist. Some GOA stocks are considered depressed, but the overall stock status of golden king crab in BSAI and GOA is unknown and biomass estimates have not been determined. Thus, potential effects on biomass of BSAI and GOA golden king crab stocks resulting from past events, direct catch, internal bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 2.2.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of blue king crab in GOA, potential effects of FMP 2.2 on biomass of this species is unknown. Survey data collected by ADF&G for certain bairdi Tanner crab stocks in western GOA show signs of possible recovery while other GOA stocks are still considered depressed. Thus, potential effects of FMP 2.2 on biomass of GOA bairdi Tanner crab as a whole cannot be determined. Red king crab populations in GOA are at historic lows according to ADF&G survey information. Considering the severely depressed state of this stock as a whole, FMP 2.2 could have conditionally significant adverse effects on the biomass of red king crab populations in GOA, since no signs of recovery have been observed to date.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Adverse effects of past fishing mortality on biomass of bairdi Tanner, blue king, and red king crab stocks in GOA may still exist, as recovery of depressed stocks has not been determined.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Survey data collected by ADF&G in specific areas of the GOA have shown depressed stock status for bairdi Tanner and blue king crab, but their overall stock status in GOA is currently unknown. Thus, the potential effects of these fisheries on biomass of bairdi Tanner and blue king crab stocks cannot be determined. GOA stocks of red king crab are considered severely depressed according to current ADF&G surveys. The depressed nature of these stocks, in addition to external mortality associated with state fisheries (directed, subsistence, and scallop), could adversely impact recovery and sustainability of red king crab stocks in GOA. Potential effects of long-term climate change and regime shifts on biomass have not been determined.

- **Cumulative Effects.** ADF&G crab management plans are responsive to changes in stock status and quota-setting processes account for crab bycatch in other state and federal fisheries. However, persistent past effects on bairdi Tanner, red king, and blue king crab stocks in GOA may still exist. Some GOA stocks of bairdi Tanner and blue king crab are considered depressed, but their overall stock status is unknown. Thus, potential effects on biomass of bairdi Tanner and blue king crab in GOA resulting from past events, direct catch, bycatch, and reasonably foreseeable future external events cannot be determined at this time for FMP 2.2. Potential effects on biomass of red king crab in GOA resulting from past events, internal bycatch, and reasonably foreseeable future external events are considered conditionally significant adverse due to the already severely depressed nature of these stocks and apparent lack of recovery observed to date.

Change in Reproductive Success

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** These stocks are currently considered depressed and in some instances overfished. Changes in reproductive success within BSAI crab populations may be an underlying factor in the depressed nature of these stocks. However, a relationship between reproductive success and depressed stock status has yet to be determined. Therefore, the potential effects of FMP 2.2 on changes to reproductive success cannot be determined.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries. The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. Past effects may still exist, as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab, scallop, and subsistence fisheries continue to occur. Crab seasons are set as to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of bairdi Tanner, opilio Tanner, red king, and blue king crab stocks in BSAI. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at this time. These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on crab populations in the BSAI may still exist and stocks are considered depressed with no signs of recovery to date. The current baseline condition for blue king and bairdi Tanner crab is unknown and a direct causation between red king crab reproductive success and depressed stock status cannot be concluded at this time. Therefore the potential effects on reproductive success resulting from past, present, and future events are unknown for all stocks under FMP 2.2.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, potential effects of FMP 2.2 on changes to reproductive success cannot be determined.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. Crab bycatch is common in yellowfin sole and Pacific ocean perch fisheries. During the 1960s, foreign fleets in BSAI experienced record catch of yellowfin sole and Pacific ocean perch. It is inferred that bycatch of crab during this time increased proportionally with the direct catch of these fisheries, but the composition of this catch is unknown. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Current stock status of BSAI and GOA golden king crab has not been determined, so potential past effects on reproductive success are also unknown.

- **Reasonably Foreseeable Future External Effects.** State crab, scallop, and subsistence fisheries continue to occur, and are managed by ADF&G in cooperation with NOAA Fisheries. Crab seasons are set as to avoid mating and molting periods, so these fisheries are not considered contributing factors to changes in reproductive success of golden king crab. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Crab seasons are set to avoid mating and molting periods. However, persistent past effects on golden king crab populations in the BSAI and GOA are not known. Potential effects on reproductive success resulting from past, present, and future events are unknown for FMP 2.2.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of blue king crab in GOA, potential effects of FMP 2.2 on changes to reproductive success cannot be determined. Survey data collected by ADF&G for certain bairdi Tanner crab stocks in western GOA show signs of possible recovery while other GOA stocks are still considered depressed. Red king crab populations in GOA are at historic lows according to ADF&G survey information. Changes in reproductive success within GOA crab populations may be an underlying factor in the depressed nature of these stocks. However, a direct causation between reproductive success and depressed stock status cannot be concluded at this time. Potential effects of FMP 2.2 on changes to reproductive success cannot be determined for bairdi Tanner and red king crab populations in GOA.

- **Persistent Past Effects.** Direct catch and bycatch of crab are associated with past foreign fisheries. The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have indirectly impacted reproductive success of these stocks by removing vital brood stocks and/or adversely impacting spawning and nursery habitat as a result of bottom trawling. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. Crab seasons are set as to avoid mating and molting period so these fisheries are not considered contributing factors to changes in reproductive success of these stocks. The potential effects of long-term climate change and regime shifts on reproductive traits of crab are unknown.

- **Cumulative Effects.** Although crab seasons are set to avoid mating and molting periods, persistent past effects on crab populations in the GOA may still exist, and some stocks are considered depressed with no signs of recovery to date. Thus, potential effects on reproductive success resulting from past, present, and future events are unknown for FMP 2.2.

Change in Prey Availability

Bairdi Tanner, Opilio Tanner, Red King, Blue King, and Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Diet composition of crab has not been determined, but crab are known to be benthic feeders. Competition for prey species of crab resulting from groundfish fisheries' catch has not been shown, and it is unclear if FMP 2.2 would impact prey structure and availability for all species of crab throughout BSAI and GOA. Thus, potential effects of FMP 2.2 on changes in prey availability cannot be determined.

- **Persistent Past Effects.** Crab are benthic feeders and generally feed on invertebrates. Catch of crab prey in current and past groundfish fisheries is minimal. Thus, past effects on crab prey structure and availability in BSAI and GOA have not been identified.

- **Reasonably Foreseeable Future External Effects.** State crab, scallop, and subsistence fisheries continue to occur, and are managed by ADF&G in cooperation with NOAA Fisheries. Competition for prey species of crab resulting from fisheries' catch has not been shown and is not considered a contributing factor to changes in prey availability. Rebuilding plans currently in effect in BSAI do not address crab prey structure and availability and are not considered contributing factors to potential changes in prey availability. Long-term climate change and regime shifts may impact crab prey structure depending on the direction of the change. However, it is impossible to determine the effects that these changes may have on crab populations throughout BSAI and GOA.

- **Cumulative Effects.** Diet composition of crab has not been determined and potential changes to prey structure, resulting from direct catch, bycatch, and other future events cannot be determined for all species of crab in BSAI and GOA for FMP 2.2.

Change in Habitat

Bairdi Tanner, Opilio Tanner, Red King, and Blue King Crab in BSAI

- **Direct/Indirect Effects.** These stocks are currently considered depressed and in some instances, overfished. However, a direct causation between habitat and depressed stock status cannot be concluded at this time. Numerous ADF&G management measures, rebuilding plans, trawl closures, and conservation areas have been implemented to address declining and overfished crab stocks in the BSAI. It is inferred that current crab management plans are mitigating past habitat disruption and providing protection for crab stocks. Potential effects of FMP 2.2 on changes to habitat are considered insignificant.

- **Persistent Past Effects.** The Japanese pot sanctuary area was established as a no-trawl zone in the early 1960s, but was eliminated in 1976 with the implementation of the MSA. This area coincided with the distribution of mature female red king crab brood stocks in the Bering Sea, and the removal of this protection has been suggested as having long-term detrimental effects on red king crab populations (Dew and McConnaughey In review). The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have directly or indirectly impacted spawning and nursery habitat areas, as a result of trawling and using other types of fishing gear that interact with bottom habitat. Past effects may still exist as these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur. These fisheries are considered potentially adverse factors in changes to crab habitat based on the lack of recovery that has been observed for these stocks under current management plans. Formal stock rebuilding plans are in place for BSAI bairdi and opilio Tanner crab stocks. St. Matthew Island blue king crab stock has a rebuilding plan in effect. In the Pribilof Islands, a blue king crab rebuilding plan is currently being developed, but is not in effect at the time of this writing . These rebuilding plans may have beneficial effects on recovery of these stocks as a whole over time and offer protection of critical habitat. BSAI red king crab stocks do not have rebuilding plans in effect, and the population is currently considered depressed, and possible habitat-related effects have not been determined. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors.

- **Cumulative Effects.** Persistent past effects on crab habitat in the BSAI may still exist and stocks are considered depressed with no signs of recovery to date. Although some of the known habitat areas of BSAI crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. Thus, potential effects on crab habitat resulting from past, present, and future events cannot be determined for FMP 2.2.

Golden King Crab in BSAI and GOA

- **Direct/Indirect Effects.** Due to lack of survey information for determining current stock status of golden king crab in BSAI and GOA, it is difficult to identify habitat-related effects as they pertain

to changes in these crab populations throughout BSAI and GOA. Potential effects of FMP 2.2 to crab habitat are unknown.

- **Persistent Past Effects.** The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Current stock status of BSAI and GOA golden king crab has not been determined, so potential past effects on essential habitat are also unknown.

- **Reasonably Foreseeable Future External Effects.** State crab fisheries, scallop fisheries, and subsistence fisheries continue to occur and are considered potentially adverse factors in changes to crab habitat based on the lack of recovery that has been observed for many of the crab stocks under current management plans. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors.

- **Cumulative Effects.** It is unclear if persistent past effects on golden king crab habitat in the BSAI and GOA exist, and some GOA golden king crab stocks are considered depressed. Although some of the known habitat areas of BSAI and GOA crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. Thus, potential effects on golden king crab habitat resulting from past, present, and future events cannot be determined for FMP 2.2 without first establishing the population status of this species.

Bairdi Tanner, Red King, and Blue King Crab in GOA

- **Direct/Indirect Effects.** Red king and bairdi Tanner stocks in the GOA are currently considered depressed. Blue king crab stock status is unknown, but presumed to be depressed based on limited survey data. Although a relationship between changes in habitat and depressed stock status has not been determined, numerous ADF&G management measures, rebuilding plans, trawl closures, and conservation areas have been implemented to address declining crab stocks in the GOA. It is inferred that current crab management plans are mitigating past habitat disruption and providing protection for crab stocks. Therefore, the potential effects of FMP 2.2 on changes to habitat for bairdi Tanner, red king, and blue king crab stocks in GOA are considered insignificant.

- **Persistent Past Effects.** The U.S. initiated bilateral agreements with Japan and Russia in the mid-1960s in order to reduce gear conflicts and allocate crab resources between state crab fisheries and foreign fisheries. These bilateral agreements are thought to have been marginal management measures providing no benefit or protection to crab stocks overall. Thus, past fisheries may have directly or indirectly impacted spawning and nursery habitat as a result of bottom trawling. Past effects may still exist, as some of these stocks have not shown signs of recovery to date.

- **Reasonably Foreseeable Future External Effects.** State crab, scallop, and subsistence fisheries continue to occur and are considered potentially adverse factors in changes to crab habitat based on the lack of recovery that has been observed for these stocks under current management plans. Long-term climate change and regime shifts are not expected to directly affect the physical habitat and are not considered contributing factors in possible changes to GOA crab habitat.

- **Cumulative Effects.** Persistent past effects on crab habitat in the GOA may still exist and stocks are considered depressed with no signs of recovery to date. Although some of the known habitat areas of GOA crab are currently protected by no trawl zones and conservation zones, it is possible that other critical habitat areas are not included in these measures. Thus, potential effects on GOA bairdi Tanner, red king, and blue king crab habitat, resulting from past, present, and future events, cannot be determined for FMP 2.2.

4.6.3 Other Species Alternative 2 Analysis

The other species category consists of the following species:

- Squid (order Teuthoidea).
- Sculpin (family Cottidae).
- Shark (*Somniosus pacificus, Squalus acanthias, Lamna ditropis*).
- Skate (genera *Bathyraja and Raja*).
- Octopi (*Octopus dofleini,Opistholeutis california,* and *Octopus leioderma*).

An aggregate TAC limits the catch of species in this category. Within the other species category, only shark are identified to the species level by fishery observers. Furthermore, accuracy of catch estimates depends on the level of coverage in each fishery. Estimates of observer coverage in the BSAI is 70-80 percent, whereas the GOA has only approximately 30 percent observer coverage. Coverage can also vary for certain target fisheries and vessel sizes (Gaichas 2002). Further description of this management is described in detail in Section 3.5.3.

Formal stock assessments for other species are not currently conducted in the BSAI and GOA and biomass estimates for the species included in this category are limited and often unreliable. Thus, changes in total biomass, reproductive success, genetic structure of population, habitat, or mortality rates under any FMP alternative cannot be determined due to lack of a baseline condition. There are numerous direct and indirect effects that may impact the current and future status of individual species within this group and/or this group as a whole. These effects are summarized in the section that follows.

Direct/Indirect Effects FMP 2.1 – Other Species

Direct and indirect effects for other species include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown, because information on stock status is lacking in order to determine how these stocks respond to changes in catch. For many non-target species, the differences in catch between the comparative baseline and FMP 2.1 are relatively small, such that diverse alternatives may have similar (unknown) effects on each stock.

Under FMP 2.1, total catch of BSAI squid and other species is predicted to increase by several thousand tons per year. Catch of GOA other species is predicted to triple. This is due to predicted increases in catches of the target species that other species are caught with. Most of this increase is predicted in the catch of sculpin

in the BSAI and skate in the GOA. Catch projections for specific groups within BSAI and GOA other species are presented below.

Squid

In the BSAI, squid catch is predicted to double initially and then decrease to just above the current level over the five projection years, likely following trends in the pollock fishery. The 2003 catch exceeds the historical OFL set for squid based on Tier 6 criteria, and might result in additional management measures being applied relative to those modeled if these were actual catches and if the same OFL were set in the future. Squid catch is predicted to triple over the five-year projection period in the GOA, likely reflecting increasing catches in the pollock fishery. However, observed GOA squid catch has been low historically, so tripling may not cause different population impacts than current catch levels.

Sculpin

Catches of BSAI sculpin are predicted to double, increasing from the current level of 7,000 mt per year to 13,000-15,000 mt per year. While this seems substantial, the effects on any of the approximately 50 different species of sculpin in this group are unpredictable because the effects of current levels of catch are unknown and species composition is currently unknown as well.

GOA sculpin catch is predicted to double over the projection period, reaching approximately 1,000 mt.

Shark

BSAI shark species have been separated into Pacific sleeper shark, salmon shark, dogfish, and other shark. Catches of sleeper shark are predicted to double initially and then decrease to roughly current levels, as are catches of salmon shark and other shark. Dogfish catches, which are low in the BSAI under current management, are predicted to decrease and then increase to current levels during the five year projection period under FMP 2.1. As in the BSAI, shark catches in the GOA are partitioned into Pacific sleeper shark, salmon shark, dogfish, and other shark. While all shark catch in the GOA is predicted to be relatively low, catches of other shark are predicted to increase by an order of magnitude. Catches of salmon shark are predicted to decrease slightly, and catches of sleeper shark and dogfish will increase relative to current levels.

Skate

Skate currently make up the largest portion of bycatch for the other species complex. The catch of BSAI skate is predicted to decrease by nearly 3,000 mt initially within the first three projection years, and return to current levels by the end of the modeled period. GOA Skate catch is predicted to more than double to over 4,300 mt; an increase which could warrant increased management attention.

Adoption of Amendment 63 by NPFMC would result in the separation of GOA skate species from the other species complex. In turn, they would be added to the target species category with an ABC and TAC set for skates and skate complexes (NPFMC 2003a). The NPFMC has requested a separate OFL and ABC for combined big and longnose skates in the central GOA due to concerns regarding a developing fishery. Efforts to address existing data gaps for skate species are underway and improved collection of data is expected under this amendment.

Octopi

Octopus catch in the BSAI is predicted to remain stable at 200-300 mt per year. However, observed GOA octopus catch has been low historically, so potential increases may not cause different population impacts than current catch levels. The trace amounts of octopus catch reported in the GOA are predicted to increase over the projection period, with no discernable differences in the currently unknown population impacts.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with Alternative 2, FMP 2.1 is shown in Table 4.5-43. Table 4.6-2 provides a summary of the significance ratings for all effects. For further information on persistent past effects included in this analysis see Section 3.5.3 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA other species is unknown under Alternative 2, FMP 2.1. The current baseline condition is unknown and species-specific catch information is lacking for this complex, since species identification does not occur in the fisheries.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. It is difficult to determine how much protection is afforded by a TAC set with the use of data-poor criteria.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to the specific species within this complex are unknown, since the current baseline condition has not been determined. Long-term climate change and regime shifts are not expected to result in direct mortality.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on other Species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA other species are unknown under Alternative 2, FMP 2.1. The current baseline condition is unknown and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a

species group could be disproportionately exploited while the overall aggregate Other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. This possible overexploitation could have impacts to reproductive success, if sex-ratios of these species are significantly altered, or if sex-specific aggregations are overfished. However, persistent past effects on the population have not been determined.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown, since the current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to reproductive success on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of the other species population in BSAI and GOA are unknown under Alternative 2, FMP 2.1. The current baseline condition is unknown, and genetic structure of species-specific populations within this complex has not been determined.

- **Persistent Past Effects.** The current genetic composition of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate Other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. This possible overexploitation could have impacts to the genetic structure of the population if genetic composition within these species groups has been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing effects to changes in genetic structure of populations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the other species complex resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA other species is unknown under Alternative 2, FMP 2.1. The current baseline condition is unknown and species-specific catch information is lacking for this complex, since species identification does not occur in the fisheries. Formal stock assessments are not conducted for other species, and most biomass estimates for BSAI and GOA other species are unreliable or not known.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate Other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to the specific species within this complex are unknown, since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of changes in biomass on this species complex as a whole are unknown. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Habitat

- **Direct/Indirect Effects.** The potential effects of habitat changes to BSAI and GOA other species is unknown under Alternative 2, FMP 2.1. A current baseline condition has not been determined.

- **Persistent Past Effects.** Under current management in the BSAI and GOA, impacts to habitat could be occurring for some of the species within the other species complex. However, the species included in this complex have diverse habitat preferences and distribution patterns. Although

persistent past effects potentially impacting habitat for some or all of these species could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to habitat of the specific species within this complex are unknown. Long-term climate change and regime shifts are not expected to result in significant change to physical habitat and are not considered contributing factors to potential effects.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. These species also have diverse habitat preferences. Although persistent past effects potentially impacting habitat could exist, without a baseline condition established, they remain unknown. The combined effects of changes to habitat on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Direct/Indirect Effects FMP 2.2 – Other Species

Direct and indirect effects for Other species include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown, because information on stock status is lacking in order to determine how these stocks respond to changes in catch. For many non-target species, the differences in catch between the comparative baseline and FMP 2.2 are relatively small, such that diverse alternatives may have similar (unknown) effects on each stock.

Under FMP 2.2, total catch of BSAI squid and other species and GOA other species is predicted to increase by several thousand tons per year. This is due to predicted increases in catches of the target species that other species are caught with. Most of this increase is predicted in the catch of skate and sculpin in both areas. Catch projections for specific groups within BSAI and GOA other species are presented below.

Squid

In the BSAI, squid catch is predicted to nearly double and then decrease to just above the current level over the five projection years, likely following trends in the pollock fishery. Squid catch is predicted to slowly increase to double its current magnitude over the five year projection period in the GOA, likely reflecting increasing catches in the pollock fishery. However, observed GOA squid catch has been low historically, so doubling may not cause different population impacts than current catch levels.

Sculpin

Catches of BSAI sculpin are predicted to increase by about 1,000 mt relative to current catches. GOA sculpin catch is predicted to increase by 200 mt per year over the projection period.

Shark

BSAI shark species have been separated into Pacific sleeper shark, salmon shark, dogfish, and other shark. Catches of all of these species are predicted to increase slightly and then decrease to close to current levels

under FMP 2.2. As in the BSAI, shark catches are partitioned into Pacific sleeper shark, salmon shark, dogfish, and other shark. While all shark catch in the GOA is predicted to be relatively low, catches of other shark are predicted to increase by an order of magnitude. Catches of Pacific sleeper shark and salmon shark are predicted to decrease slightly, and catches of dogfish will remain relatively similar to current levels.

Skate

The catch of BSAI skate is predicted to increase by nearly 2,000 mt to over 21,000 mt for all projection years. The increased catch of skates may reflect increased catches in both longline fisheries for Pacific cod and in bottom trawl fisheries for cod and flatfish. Skate catch in GOA is predicted to increase by about 1,000 mt, which is the same order of magnitude as current catches and may warrant increased management attention if it actually happened.

Adoption of Amendment 63 by NPFMC would result in the separation of GOA skate species from the other species complex. In turn, they would be added to the target species category with an ABC and TAC set for skates and skate complexes (NPFMC 2003a). The NPFMC has requested a separate OFL and ABC for combined big and longnose skates in the Central GOA due to concerns regarding a developing fishery. Efforts to address existing data gaps for skate species are underway and improved collection of data is expected under this amendment.

Octopi

Octopus catch in the BSAI is predicted to remain stable at about 500 mt per year. The trace amounts of octopus catch reported in the GOA are predicted to decrease slightly over the projection period, with no discernable differences in the currently unknown population impacts.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with Alternative 2, FMP 2.2 is shown in Table 4.5-43. For further information on persistent past effects included in this analysis see Section 3.5.3.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA other species is unknown under Alternative 2, FMP 2.2. The current baseline condition is unknown and species-specific catch information is lacking for this complex since species identification does not occur in the fisheries.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate Other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. It is difficult to determine how much protection is afforded by a TAC set with the use of data-poor criteria.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take

other species as bycatch. However, potential impacts to the specific species within this complex are unknown since current baseline condition has not been determined. Long-term climate change and regime shifts are not expected to result in direct mortality.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success of BSAI and GOA other species are unknown under Alternative 2, FMP 2.2. The current baseline condition is unknown, and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. This possible overexploitation could have impacts to reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. However, persistent past effects on the population have not been determined.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown, since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to reproductive success on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of the other species population in BSAI and GOA are unknown under Alternative 2, FMP 2.2. The current baseline condition is unknown, and genetic structure of species-specific populations within this complex has not been determined.

- **Persistent Past Effects.** The current genetic composition of the other species complex is unknown. It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate Other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. This possible overexploitation could have impacts to the genetic structure of the population if genetic composition within these species groups has been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing effects to changes in genetic structure of populations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the other species complex resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA other species is unknown under Alternative 2, FMP 2.2. The current baseline condition is unknown and species-specific catch information is lacking for this complex since species identification does not occur in the fisheries. Formal stock assessments are not conducted for other species, and most biomass estimates for BSAI and GOA other species are unreliable or not known.

- **Persistent Past Effects.** It is possible under current other species management in the BSAI and GOA, that a species or even a species group could be disproportionately exploited while the overall aggregate Other species TAC is not reached. In addition, the highest observed catches of non-target species are within the categories receiving the least intensive management under the current FMP: other species and nonspecified species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to the specific species within this complex are unknown, since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of the other species depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how the other species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of changes in biomass on this species complex as a whole are unknown. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

Change in Habitat

- **Direct/Indirect Effects.** The potential effects of habitat changes to BSAI and GOA other species is unknown under Alternative 2, FMP 2.2. A current baseline condition has not been determined.

- **Persistent Past Effects.** Under current management in the BSAI and GOA, impacts to habitat could be occurring for some of the species within the other species complex. However, the species included in this complex have diverse habitat preferences and distribution patterns. Although persistent past effects potentially impacting habitat for some or all of these species could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries, IPHC halibut longline fishery, and state sport halibut fishery continue to take other species as bycatch. However, potential impacts to habitat of the specific species within this complex are unknown. Long-term climate change and regime shifts are not expected to result in significant change to physical habitat and are not considered contributing factors to potential effects.

- **Cumulative Effects.** For all members of the other species complex, life history and distribution information are minimal in both the BSAI and the GOA. These species also have diverse habitat preferences. Although persistent past effects potentially impacting habitat could exist, without a baseline condition established, they remain unknown. The combined effects of changes to habitat on other species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown.

4.6.4 Forage Fish Alternative 2 Analysis

The BSAI and GOA FMPs were amended in 1998 to establish a forage species category to prevent the development of directed fisheries on these ecologically important non-target species. Forage fish are described in more detail in Section 3.5.4.

Direct/Indirect Effects of FMP 2.1 – BSAI and GOA Forage Fish

Total Biomass

Total biomass of BSAI and GOA forage fish is unknown at this time. Under FMP 2.1, the ban on a directed fishery on forage fish would be repealed. If an intensive, directed fishery for forage fish were developed, it is possible to envision an adverse impact on forage fish populations. On the large scale, due to economic and biological factors, it is unlikely that a fishery with enough intensity would be able to develop to reduce forage fish populations to below a sustainable level. However, it is possible that a local fishery could develop and

create localized forage fish depletions that could place competitive strains on predator populations (seabirds, marine mammals, groundfish). Without the development of a forage fish fishery, the effect of FMP 2.1 on the total biomass of forage fish is thought to be insignificant.

Spawning Biomass

Spawning biomass of BSAI and GOA forage fish is unknown at this time. Under FMP 2.1, it is possible for a fishery to develop on forage fish. If a fishery were developed, the spawning biomass could decrease from their current levels due to increased fishing effort. However, unless the fishery was extremely intensive it would most likely not significantly affect the spawning biomass.

Catch/Fishing Mortality

Under FMP 2.1, the ban on a directed fishery on forage species would be lifted. It is impossible to predict how the fishery would react to this. Even with a lifting of the ban, due to economic reasons a fishery for forage species would not necessarily commence. Therefore, the model can only forecast incidental catch rates of forage fish.

Forage fish are taken in small amounts as incidental catch in several target fisheries. The bulk (> 90 percent most years) of the forage fish bycatch is made up of smelt species (Osmeridae) from the pollock fishery. In the BSAI region, model projections for FMP 2.1 indicate incidental catch of forage fish would increase considerably above the current level (Table H.4-22 in Appendix H). Over the next 5 years the pollock catch in the GOA is projected to grow rapidly under FMP 2.1 (Table H.4-41 in Appendix H). This increased pollock catch under this FMP is expected to lead to greater, yet still relatively low, incidental catches of forage fish.

Fishing mortality of BSAI and GOA forage fish is unknown at this time. Under FMP 2.1, an increase in forage fish bycatch, and hence fishing mortality, would be expected. If a directed fishery for forage fish developed under FMP 2.1, fishing mortality would increase.

Spatial/Temporal Concentration of Fishing Mortality

Little is known about the current spatial or temporal concentration of fishing mortality for forage species. It would be hypothetically possible for a directed fishery under FMP 2.1 to create localized depletions in forage fish creating competitive forces on other predator species (marine mammals, sea birds, groundfish). However, it is unknown if this type of fishery would develop for economic reasons.

Status Determination

The MSST of forage fish species is unknown at this time, but it is highly unlikely that management practices under FMP 2.1 would lead to stocks dropping below a sustainable level.

Age and Size Composition and Sex Ratio

The age and size composition of the species in the forage fish group is unknown. It is unknown how FMP 2.1 would change the age and size composition of the forage fish species. The sex ratio of forage fish is currently assumed to be 50:50. There is no information available that would suggest this would change under FMP 2.1.

Habitat-Mediated Impacts

Little is known about the relationship between forage fish and their habitat. It is unknown how any of the considered FMPs would change the suitability of the habitat occupied by forage fish.

Predation-Mediated Impacts

The predator-prey interactions of forage fish are very complex and difficult to predict. With the given data, it would be extremely difficult to accurately assess the predator-prey impacts of FMP 2.1.

Summary of Effects of FMP 2.1 – BSAI and GOA Forage Fish

Information on forage fish species is very limited. Total biomass, spawning biomass and fishing mortality are not estimated in the model used for this analysis. Therefore, only qualitative assessment of this FMP's effects on these measures can be described.

A directed fishery for forage fish is currently prohibited by Amendment 36 and 39 in the BSAI and GOA FMP. Under FMP 2.1 this ban would be lifted. Direct effects of FMP 2.1 would include incidental take of forage fish in other fisheries and any direct take from a fishery that may develop. It is impossible to predict how, or even if, a forage fish fishery would develop under FMP 2.1. Even with a lifting of the ban, due to economic reasons a fishery for forage species would not necessarily commence. Therefore, the model can only forecast incidental catch rates for forage fish.

The model is able to estimate future bycatch of forage fish by averaging the 1997-2001 bycatch matrix. Model output for forage fish bycatch is closely linked to pollock catch. Smelts make up the vast majority of the forage fish bycatch in the BSAI and GOA. The bulk of the smelt bycatch comes from the pollock fishery. Therefore, the projected level of incidental catch of forage fish is highly correlated with the pollock TAC set for the FMP. Under FMP 2.1 the pollock TAC is set to a more aggressive level. Pollock catch, and hence forage fish bycatch, is forecast to increase appreciably in the BSAI (Table H.4-22 in Appendix H). In the GOA the catch of pollock is also modeled to increase considerably in the next 5 years. Assuming the bycatch rate of forage fish stays constant, a large increase in the total forage fish bycatch is predicted (Table H.4-41 in Appendix H). Although the total biomass of forage fish is unknown, the amount of incidental catch predicted for FMP 2.1 is thought to be a relatively small fraction of the biomass, and unlikely to affect the abundance of the stock in either the BSAI or GOA.

As stated above, FMP 2.1 removes the ban on a directed forage fish fishery. If a fishery were to be developed, for biological and economic reasons the most likely forage species group to be exploited would be the smelts (Osmeridae). If an intensive, directed fishery for smelt was developed, it is possible to envision an adverse impact on forage fish populations. On the large scale, due to economic factors, it is unlikely that a fishery with enough intensity would be able to develop to reduce forage fish populations to below a sustainable level. However, it is possible that a fishery could create localized forage fish depletions that could place competitive stress on predator populations (seabirds, marine mammals, groundfish).

Indirect effects of FMP 2.1 include habitat disturbance and disproportionate removals of predators or prey. There is insufficient information to address the indirect effects of FMP 2.1.

Cumulative Effects Analysis of FMP 2.1 – BSAI and GOA Forage Fish

Tables 4.5-44 and 4.5-45 summarize the cumulative effects associated with FMP 2.1.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI and GOA forage fish is rated as insignificant under FMP 2.1.

- **Persistent Past Effects** have not been identified for fishing mortality in the BSAI and GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on mortality are indicated due to potentially adverse contributions of marine pollution, since acute and/or chronic pollution events could cause forage fish mortality. Climate changes and regime shifts are not considered to be contributing factors, since it is unlikely that the change in water temperatures would be of sufficient magnitude to result in mortality of forage fish (see Sections 3.5.4 and 3.10). Alaska subsistence and personal use fisheries are identified as potential adverse contributors to forage fish mortality; however, the removal of these species is expected to be minimal.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI and GOA forage fish and is rated as insignificant. Removals at projected levels are small and not expected to have a population level impact. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** The change in biomass level under FMP 2.1 is rated as unknown.

- **Persistent Past Effects** have not been identified for the change in biomass in the BSAI and GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on the change in biomass are indicated due to the potentially adverse contributions of marine pollution, since acute and/or chronic pollution events could cause forage fish mortality. Climate changes and regime shifts have been identified as having potentially beneficial or adverse contributions on the forage fish biomass level. A strong Aleutian Low and increased water temperatures tend to result in weak recruitment (see Sections 3.5.4 and 3.10). The Alaska subsistence and personal use fisheries have been identified as a potentially adverse contributor to the change in biomass level of BSAI and GOA forage fish. Subsistence and personal use fisheries concentrate mostly on the smelt species; however, it is unlikely that these fisheries would have a population level effect.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of BSAI and GOA forage fish, but the effect is unknown. Total and spawning biomass are unavailable for the forage fish species at this time.

Spatial/Temporal Concentration of Catch

- **Direct/Indirect Effects.** Under FMP 2.1, the effect of the spatial/temporal concentration of catch is unknown.

- **Persistent Past Effects** are not identified for the genetic structure of the BSAI and GOA forage fish. Climate changes and regime shifts are identified as influencing the reproductive success of BSAI and GOA forage fish. For example, some Osmeridae species have shown a decline in recruitment since the late 1970s, coinciding with the increase water temperature.

- **Reasonably Foreseeable Future External Effects** on the reproductive success of forage fish due to climate changes and regime shifts are potentially beneficial or adverse. Marine pollution has been identified as a potentially adverse contributor, since acute and/or chronic pollution events could alter the genetic structure and/or the reproductive success of BSAI and GOA forage fish. The Alaska subsistence and personal use fisheries are identified as having potentially adverse contributions to the genetic structure and reproductive success of BSAI and GOA forage species. As stated above, these fisheries mainly target smelt species. However, it is unlikely the removals in these fisheries would sufficiently large and localized, such that they would jeopardize the capacity of the stocks to maintain current population levels.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the forage fish catch; however, this effect is unknown. Information on the spatial/temporal concentration of the BSAI and GOA forage fish bycatch is currently lacking.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.1, the change in prey availability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** are identified for the change in prey availability of the BSAI and GOA forage fish stock and include climate changes and regime shifts. Crab and shrimp have shown variation in abundance associated with changes in climate and water temperatures. However, studies on most benthic invertebrates have not been conducted (see Sections 3.5.4 and 3.10).

- **Reasonably Foreseeable Future External Effects** of the climate changes and regime shifts on the BSAI and GOA forage fish stock are potentially beneficial or adverse. Marine pollution has also been identified as a potentially adverse contributor, since acute and/or chronic pollution events could reduce prey availability or prey quality and thus jeopardize the stock's ability to maintain current population levels. Alaska subsistence and personal use fisheries are identified as potentially adverse contributors to the prey availability of BSAI and GOA forage fish. However, the catch/bycatch of these species is expected to be minimal and unlikely to have a population level impact.

- **Cumulative Effects.** A cumulative effect is possible for change in prey availability; however, this effect is unknown. Information on forage fish prey interactions is insufficient.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.1, the change in habitat suitability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** identified for BSAI and GOA forage fish include climate changes and regime shifts (see Sections 3.5.4 and 3.10).

- **Reasonably Foreseeable Future External Effects** of the climate changes and regime shifts on the BSAI and GOA forage fish stock are potentially beneficial or adverse. Marine pollution has also been identified as having a potentially adverse contribution, since acute and/or chronic pollution events could cause habitat degradation and may cause changes in spawning or rearing success. Alaska subsistence and personal use fisheries are identified as potentially adverse contributors to forage fish habitat suitability (see Section 3.6).

- **Cumulative Effects.** A cumulative effect is identified for BSAI and GOA forage fish habitat suitability; however, this effect is unknown. Information of forage fish habitat and the distribution of the fisheries on these habitats is insufficient at this time.

Direct/Indirect Effects of FMP 2.2 – BSAI and GOA Forage Fish

Total and Spawning Biomass

Total and spawning biomass of BSAI and GOA forage fish is unknown at this time. The incidental catch rates predicted for FMP 2.2 is not expected to affect biomass.

Catch/Fishing Mortality

A directed fishery on forage species is prohibited by Amendment 36 and 39 in the BSAI and GOA FMPs. However, forage fish are taken in small amounts as incidental catch in several target fisheries. The bulk (>90 percent most years) of the forage fish bycatch is made up of smelt species (Osmeridae) from the pollock fishery. In the BSAI region, model projections for FMP 2.2 indicate incidental catch of forage fish would increase considerably above the current level (Table H.4-22 in Appendix H). Over the next 5 years the pollock catch in the GOA is projected to grow rapidly under FMP 2.2 (Table H.4-41 in Appendix H). This increased pollock catch under this FMP is expected to lead to greater, yet still small, incidental catches of forage fish.

Fishing mortality of BSAI and GOA forage fish is unknown at this time. As described above, forage fish bycatch and hence fishing mortality would increase under FMP 2.2. Currently, fishing mortality of forage fish is thought to be small, and the predicted increase is thought to be trivial.

Spatial/Temporal Concentration of Fishing Mortality

Little is known about the current spatial or temporal concentration of fishing mortality for forage species. It is unknown how the spatial or temporal concentration of fishing effort is expected to change under FMP 2.2.

Status Determination

The MSST of forage fish species is unknown at this time, but it is unlikely that management practices under FMP 2.2 would lead to stocks dropping below a sustainable level.

Age and Size Composition and Sex Ratio

The age and size composition of the species in the forage fish group is unknown. It is assumed that the age and size composition of forage fish would not change under FMP 2.2. The sex ratio of forage fish is assumed to be 50:50. There is no information available that would suggest this would change under FMP 2.2.

Habitat-Mediated Impacts

Little is known about the relationship between forage fish and their habitat. It is unknown how any of the considered FMPs would change the suitability of the habitat occupied by forage fish.

Predation-Mediated Impacts

The predator-prey interactions of forage fish are very complex and difficult to predict. With the given data, it would be extremely difficult to accurately assess the predator-prey impacts of FMP 2.2.

Summary of Effects of FMP 2.2 – BSAI and GOA Forage Fish

Information on forage fish species is very limited. Total biomass, spawning biomass and fishing mortality are not estimated in the model used for this analysis. Therefore, only qualitative assessment of the FMPs effects on these measures can be described.

A directed fishery for forage fish is prohibited by Amendment 36 and 39 in the BSAI and GOA FMPs. Therefore, the only direct effect of FMP 2.2 is incidental take of forage fish in other fisheries.

The model is able to estimate future bycatch of forage fish by averaging the 1997-2001 bycatch matrix. Model output for forage fish bycatch is closely linked to pollock catch. Smelts make up the vast majority of the forage fish bycatch in the BSAI and GOA. The bulk of the smelt bycatch comes from the pollock fishery. Therefore, the projected level of incidental catch of forage fish is highly correlated with the pollock TAC set for the FMP. Under FMP 2.2 the pollock TAC is set to a more aggressive level. Pollock catch, and hence forage fish bycatch, is projected to increase appreciably in the BSAI (Table H.4-22 in Appendix H). In the GOA the catch of pollock is modeled to increase considerably in the next 5 years (Table H.4-41 in Appendix H). Assuming the bycatch rate of forage fish stays constant, a significant increase in the total forage fish bycatch will result. Although the total biomass of forage fish is unknown, the amount of incidental catch predicted for FMP 2.2 is thought to be a relatively small fraction of the biomass and unlikely to affect the abundance of the stock in the BSAI or GOA.

Indirect effects of FMP 2.2 include habitat disturbance and disproportionate removals of predators or prey. There is insufficient information to address the indirect effects of FMP 2.2 (Tables 4.5-87 and 4.5-88).

Cumulative Effects Analysis of FMP 2.2 – BSAI and GOA Forage Fish

Tables 4.5-44 and 4.5-45 summarize the cumulative effects of FMP 2.2 on BSAI and GOA forage fish.

Mortality

- **Direct/Indirect Effects.** The effect of fishing mortality on the BSAI and GOA forage fish is rated as insignificant under FMP 2.2.

- **Persistent Past Effects** have not been identified for fishing mortality in the BSAI or GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on mortality are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for mortality of BSAI and GOA forage fish and is rated as insignificant. Removals at projected levels are small and not expected to have a population level impact. The combined effect of internal and external removals is unlikely to jeopardize the capacity of the stock to maintain current population levels.

Change in Biomass Level

- **Direct/Indirect Effects.** The total and spawning biomass for BSAI and GOA forage fish is unknown at this time.

- **Persistent Past Effects** have not been identified for the change in biomass in the BSAI and GOA forage fish stock.

- **Reasonably Foreseeable Future External Effects** on the change in biomass are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is possible for the change in biomass level of and GOA forage fish, but the effect is unknown. Total and spawning biomass are unavailable for the forage fish species at this time.

Spatial/Temporal Concentration of Catch

- **Direct/Indirect Effects.** Under FMP 2.2 the effect of the spatial/temporal concentration of catch is unknown.

- **Persistent Past Effects** identified for the change in reproductive success and genetic structure of the BSAI and GOA forage fish are the same as those indicated under FMP 2.1.

- **Reasonably Foreseeable Future External Effects** identified for the change in reproductive success and genetic structure of the BSAI and GOA forage fish are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is possible for the spatial/temporal concentration of the forage fish catch; however, this effect unknown. Information on the spatial/temporal concentration of the BSAI and GOA forage fish bycatch is currently lacking.

Change in Prey Availability

- **Direct/Indirect Effects.** Under FMP 2.2, the change in prey availability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** identified for the change in prey availability are the same as those indicated under FMP 2.1.

- **Reasonably Foreseeable Future External Effects** identified for the change in prey availability are the same as those indicated under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for change in prey availability, however, this effect is unknown. Information on forage fish prey interactions is insufficient.

Change in Habitat Suitability

- **Direct/Indirect Effects.** Under FMP 2.2, the change in habitat suitability for the BSAI and GOA forage fish is unknown.

- **Persistent Past Effects** identified for the change in habitat suitability are the same as those described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects** identified for the change in habitat suitability are the same as those described under FMP 2.1.

- **Cumulative Effects.** A cumulative effect is identified for BSAI and GOA forage fish habitat suitability; however, this effect unknown. Information of forage fish habitat and the distribution of the fisheries on these habitats is insufficient at this time.

4.6.5 Non-Specified Species Alternative 2 Analysis

Grenadiers have been chosen to illustrate potential effects to non-specified species because they are currently the major catch in the non-specified FMP category. Non-specified species is a huge and diverse category encompassing every species not listed in the current FMP as a target, prohibited, forage, or other species. Considering a single species group from this category, such as grenadier, cannot possibly represent the diverse effects to all species in the category. However, because information is lacking for nearly all of these groups, and they are caught in small or unknown amounts (due to a lack of reporting requirements in this category), only potential effects to grenadier are discussed.

Formal stock assessments are not conducted for grenadiers. Thus, changes in total biomass, reproductive success, genetic structure of population, habitat, or mortality rates under any FMP alternative cannot be determined due to lack of a baseline condition. Changes in bycatch of grenadiers were predicted based on modeled changes in target species catches and population trajectories (sablefish target fisheries have the most

grenadier bycatch). While changes in bycatch relative to the comparative baseline are reported here, it is important to emphasize that determinations cannot be made as to how these changes in catch actually impact grenadier populations, or whether these impacts might be adverse, beneficial, or neutral.

Direct/Indirect Effects FMP 2.1 – Non-Specified Species

Direct and indirect effects for grenadier include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown. Information on stock status is lacking, but is needed in order to determine how these stocks respond to changes in catch. For many non-target species, the differences in catch between the comparative baseline and FMP 2.1 are relatively small, such that diverse alternatives may have similar (but unknown) effects on each stock.

Under FMP 2.1, catch of grenadiers in both the BSAI and GOA is predicted to increase. In the BSAI, catches are double the currently observed level for most projection years. In the GOA, catches increase from about 11,000 mt to over 18,000 mt, a level which might warrant management attention if it were actually observed. However, even this level of catch has unknown population impacts because we do not know the species composition of the catch or the life history of any grenadier species in Alaskan waters to assess whether there would be population impacts.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with Alternative 2, FMP 2.1 is shown in Table 4.5-46. For further information on persistent past effects included in this analysis see Section 3.5.5 of this Programmatic SEIS.

<u>Mortality</u>

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA grenadier is unknown under FMP 2.1. The current baseline condition is unknown. Catch information is lacking for all members of the non-specified category, since species identification does not occur in the fisheries.

- **Persistent Past Effects.** No management or monitoring of any species in this category exists, and retention of any non-specified species is permitted. No reporting requirements for non-specified species exist, and there are no catch limitations or stock assessments. It is possible that grenadier, and all other species included in the non-specified category, in the BSAI and GOA, could be disproportionately exploited, but stock status remains unknown. Grenadier continue to constitute the largest portion on the non-target species bycatch in the GOA, and mortality is considered a persistent past effect.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, the state-managed commercial fisheries and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to specific species within this complex are unknown, since current baseline condition has not been determined. Long-term climate change and regime shifts are not considered contributing factors, as they are not expected to result in direct mortality.

- **Cumulative Effects.** For grenadiers and other species within the non-specified complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of mortality on this species complex as a whole are unknown. The combined effects of mortality on grenadiers, and other species with the non-specified complex, resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.1.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success of BSAI and GOA grenadier, and presumably all other species within the non-specified complex, are unknown under FMP 2.1. The current baseline condition is unknown, and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of grenadier is unknown. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited. However, stock status remains unknown. This possible overexploitation could have impacts on reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. This overfishing could lead to reduced recruitment. It is unknown if persistent past effects on the population exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown, since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts on the reproductive success of grenadiers (and other non-specified species) depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how grenadiers, and all other members of the non-specified category, will respond to climatic fluctuations.

- **Cumulative Effects.** For grenadiers, and all other species within the non-specified category, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to reproductive success on grenadiers and other non-specified species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.1.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of grenadier, and other species within the non-specified complex, populations in BSAI and GOA are unknown under FMP 2.1. The current baseline condition is unknown, and genetic structure of species-specific populations within this complex have not been determined.

- **Persistent Past Effects.** The current genetic composition of the non-specified species complex is unknown. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA, could be disproportionately exploited. However, stock status remains unknown. This possible overexploitation could have impacts on the genetic structure of the population if genetic composition within these species groups has been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, their potential impacts to genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing factors in changes to genetic structure of populations.

- **Cumulative Effects.** For grenadiers, and all members of the non-specified species category, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex are unknown, and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the non-specified species complex resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.1.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA grenadiers is unknown under FMP 2.1. The current baseline condition is unknown for all members of the non-specified complex, and species-specific catch information is lacking since species identification does not occur in the fisheries. Formal stock assessments are not conducted and biomass estimates in the BSAI and GOA for grenadiers, other than those conducted since 1999 for the giant grenadier, are not known.

- **Persistent Past Effects.** It is possible that grenadier, and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited. However, stock status remains unknown. The current non-management of grenadiers could mask declines in individual grenadier species, and lead to overfishing of a given grenadier species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, potential impacts to the specific species within this complex are unknown, since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of grenadiers, and all other members of the non-specified group, depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how these non-specified species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the non-specified species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries, and potential impacts of changes in biomass to grenadier and all other non-specified species are unknown. Although persistent past effects of changes to biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on BSAI and GOA grenadiers, and all other species in the non-specified group, resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.1.

Direct/Indirect Effects FMP 2.2 – Non-Specified Species

Direct and indirect effects for grenadier include mortality along with changes in reproductive success, genetic structure of population, and habitat. The significance of these effects caused by changes in catch for any of these non-target species groups are unknown, because information on stock status is lacking in order to determine how these stocks respond to changes in catch. For many non-target species, the differences in catch between the comparative baseline and FMP 2.2 are relatively small, such that diverse alternatives may have similar (unknown) effects on each stock.

Under FMP 2.2, catch of grenadiers in both the BSAI and GOA is predicted to remain within or slightly above the currently observed range. In both areas, grenadier catch is predicted to increase slightly initially and then decrease, following trends in the sablefish fishery.

Cumulative Effects Analysis

A summary of the cumulative effects analysis associated with Alternative 2, FMP 2.2 is shown in Table 4.5-46. For further information on persistent past effects included in this analysis see Section 3.5.5 of this Programmatic SEIS.

Mortality

- **Direct/Indirect Effects.** The potential effect of fishing mortality on BSAI and GOA grenadier is unknown under FMP 2.2. The current baseline condition is unknown. Catch information is lacking for all members of the non-specified category, since species identification does not occur in the fisheries.

- **Persistent Past Effects.** No management or monitoring of any species in this category exists, and retention of any non-specified species is permitted. No reporting requirements for non-specified species exist, and there are no catch limitations or stock assessments. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited, but stock status remains unknown. Grenadier continue to constitute the largest portion on the non-target species bycatch in the GOA, and mortality is considered a persistent past effect.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, the state-managed commercial fisheries and IPHC halibut longline fishery continue to take grenadier and other non-specified species as bycatch. However, potential impacts to specific species within this complex are unknown, since current baseline condition has not been determined. Long-term climate change and

regime shifts are not considered contributing factors, as they are not expected to result in direct mortality.

- **Cumulative Effects.** For grenadiers and other species within the non-specified complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of mortality on this species complex, as a whole are unknown. The combined effects of mortality on grenadiers, and other species with the non-specified complex, resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.2.

Change in Reproductive Success

- **Direct/Indirect Effects.** The potential effects of changes in reproductive success on BSAI and GOA grenadier, and presumably all other species within the non-specified complex, are unknown under FMP 2.2. The current baseline condition is unknown, and species-specific reproductive status has not been determined.

- **Persistent Past Effects.** Current reproductive status of grenadier is unknown. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited. However, stock status remains unknown. This possible overexploitation could have impacts to reproductive success if sex-ratios of these species are significantly altered or if sex-specific aggregations are overfished. This overfishing could lead to reduced recruitment. It is unknown if persistent past effects on the population exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, potential impacts to reproductive success of the specific species within this complex are unknown, since current baseline condition and species-specific reproductive status have not been determined. Long-term climate change and regime shifts could have impacts to the reproductive success of grenadiers (and other non-specified species) depending on the direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how grenadiers, and all other members of the non-specified category, will respond to climatic fluctuations.

- **Cumulative Effects.** For grenadiers, and all other species within the non-specified category, life history and distribution information are minimal in both the BSAI and the GOA. Current reproductive status of species with this complex are unknown, and persistent past effects have not been identified. The combined effects of changes on reproductive success of grenadiers and other non-specified species resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.2.

Change in Genetic Structure of Population

- **Direct/Indirect Effects.** The potential effects of changes in genetic structure of grenadier and other species within the non-specified complex populations in BSAI and GOA are unknown under

FMP 2.2. The current baseline condition is unknown, and genetic structure of species-specific populations within this complex has not been determined.

- **Persistent Past Effects.** The current genetic composition of the non-specified species complex is unknown. It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited. However, stock status remains unknown. This possible overexploitation could have impacts on the genetic structure of the population, if genetic composition within these species groups has been significantly altered. It is unclear if persistent past effects on the populations exist.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, their potential impacts on genetic structure of the specific species' populations within this complex are unknown. Long-term climate change and regime shifts are not expected to result in direct mortality and would not be considered contributing factors in changes to genetic structure of populations.

- **Cumulative Effects.** For grenadiers, and all members of the non-specified species category, life history and distribution information are minimal in both the BSAI and the GOA. Current genetic structure of species-specific populations within this complex is unknown, and persistent past effects have not been identified. The combined effects of changes to genetic structure of populations within the non-specified species complex resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.2.

Change in Biomass

- **Direct/Indirect Effects.** The potential effect of change in biomass on BSAI and GOA grenadiers is unknown under FMP 2.2. The current baseline condition is unknown for all members of the non-specified complex. Species-specific catch information is lacking, since species identification does not occur in the fisheries. Formal stock assessments are not conducted, and biomass estimates in the BSAI and GOA for grenadiers, other than those conducted since 1999 for the giant grenadier, are not known.

- **Persistent Past Effects.** It is possible that grenadier and all other species included in the non-specified category in the BSAI and GOA could be disproportionately exploited. However, stock status remains unknown. The current non-management of grenadiers could mask declines in individual grenadier species, and lead to overfishing of a given grenadier species. Although persistent past effects potentially impacting biomass could exist, without a baseline condition established, they remain unknown.

- **Reasonably Foreseeable Future External Effects.** In the BSAI and GOA, state-managed commercial fisheries (specifically sablefish and Greenland turbot longline) and IPHC halibut longline fishery continue to take grenadier (and other non-specified species) as bycatch. However, potential impacts to the specific species within this complex are unknown, since current baseline condition has not been determined. Long-term climate change and regime shifts could have impacts on the biomass of grenadiers, and all other members of the non-specified group, depending on the

direction of the shift. It has been shown in other aquatic species that warm trends favor recruitment while cool trends weaken recruitment, but it is currently not known how these non-specified species will respond to climatic fluctuations.

- **Cumulative Effects.** For all members of the non-specified species complex, life history and distribution information are minimal in both the BSAI and the GOA. Species identification does not occur in the fisheries and potential impacts of changes in biomass to grenadier and all other non-specified species are unknown. Although persistent past effects of changes to biomass could exist, without a baseline condition established, they remain unknown. The combined effects of these changes on BSAI and GOA grenadiers, and all other species in the non-specified group, resulting from internal bycatch and reasonably foreseeable future external events (both human controlled and natural) are unknown for FMP 2.2.

4.6.6 Habitat Alternative 2 Analysis

Alternative 2 seeks to maximize biological and economic yield from the groundfish fisheries by adopting a more aggressive harvest policy for groundfish stocks. Since this policy would result in increased fishing effort, more disturbance to benthic habitat is expected.

Direct/Indirect Effects of FMP 2.1

In addition to having a more aggressive harvest policy, FMP 2.1 illustrates a scenario where the agency repeals the various closure areas currently in place, with the exception of those required to protect Steller sea lions. Figure 4.2-2 illustrates the year-round closures in the BSAI and GOA management areas. In this FMP scenario, the fishery would be returned to an open access regime, where closures, gear restrictions, and PSC limits are repealed.

Direct and indirect effects of the FMP on habitat are discussed under the topics of changes to living habitat through direct mortality or benthic organisms and changes to benthic community structure through benthic community diversity and geographic diversity of impacts and protection. Due to differences in habitat type, the BSAI and GOA are rated and discussed separately.

Changes to Living Habitat – Direct Mortality of Benthic Organisms

In the GOA, based on the multi-species model, the catch of most living habitats is projected to increase under FMP 2.1 (Table 4.5-48). However, catch of coral in the GOA is projected to decrease. This decrease in the model projection for coral is due to a constraint in the aggregated rockfish fishery catch (Jim Ianelli, AFSC, personal communication). In the baseline, bycatch of corals is highest in the aggregated rockfish fishery. As with FMP 1, we believe a more realistic prediction is that bycatch levels under FMP 2.1 would be about the same or would increase due to increases in groundfish TACs relative to the baseline. In the BSAI, some bycatch levels of coral increased and others decreased in the model projections. A more realistic prediction under FMP 2.1 is that bycatch levels would be about the same or would perhaps increase relative to the baseline. Reliable abundance estimates are not available for most living substrates, and the level of abundance of living habitat species needed to sustain their functional role as habitat for groundfish is not known. Some of these organisms have life-history traits that make them especially sensitive to fishing removals. The long-lived nature of corals and perhaps some sponges, in particular, makes them susceptible

to permanent eradication in fished areas. Continued bycatch and damage at increased levels in FMP 2.1 could have long-term negative consequences to habitat quality.

Conceptual deductions from the habitat impacts model yield the following inferences:

- **Bering Sea.** Whether opening up new areas to fishing will result in an increased mean impact level, E, depends on habitat sensitivity parameters q, q_H, and densities of target species and habitat. The model indicates that for lower values of q and q_H (longer recovery times) catch changes faster than the equilibrium impact level for a given change in effort than at higher (short habitat recovery time) values for these parameters. Lower values for sensitivity also result in a greater impact E for a given effort level. Therefore, if sensitivity values are low, opening new areas will likely result in an increase in mean impact level, and the impact will be high. For shorter recovery times, impacts will be less severe, while there is more chance of a decrease in mean impact level with the opening of new areas. A decrease in mean impact level is beneficial, and impact severity may not be high enough to be of concern. In the former case, higher mean impact levels in combination with more severe impacts will result in detrimental impacts of concern. In addition, increased TACs as projected for FMP 2.1 will lead to greater fishing effort, which would increase impact level. Based on these results, we conclude that there would be significantly adverse change in mortality and damage to living habitat as a result of FMP 2.1.

- **Aleutian Islands.** The same situation exists in the Aleutian Islands as described above for the Bering Sea. However, a detrimental scenario is more probable in this region due to a greater likelihood of slow recovering organisms impacted. Based on these results, we conclude that there would be significantly adverse change in mortality and damage to living habitat as a result of FMP 2.1.

- **GOA.** The situation in the GOA is intermediate to the situations in the Bering Sea and in the Aleutian Islands in regard to likelihood of detrimental impacts to slow recovering organisms. It is concluded that there would be significantly adverse change on mortality and damage to living habitat as a result of FMP 2.1.

<u>Changes to Benthic Community Structure – Benthic Community Diversity and Geographic Diversity of Impacts and Protection</u>

- **Bering Sea.** Baseline closed areas are eliminated in example FMP 2.1. Table 4.5-49 shows that of the Bering Sea fishable area, 7.6 percent is closed to bottom trawling under FMP 2.1. Figure 4.6-1 shows areas closed to trawling only at various times of the year under this FMP, while Figure 4.6-2 depicts those areas closed to fixed gear only. The eliminated closure areas were adjacent to areas (e.g., historic cluster) of intermediate fishing intensity and, therefore, provided some diversity of impact in the habitat found along the boundary. They also protected crab, halibut, and other prohibited species habitat. Thus, the predicted effect of FMP 2.1 on benthic community diversity is significantly adverse relative to the existing baseline due to eliminating the closed areas. The effects of FMP 2.1 on geographic diversity of impacts are predicted to be conditionally significant adverse.

- **Aleutian Islands.** Under FMP 2.1, similar to the baseline, there are no significant notable marine reserves except for shallow areas near sea lion rookeries, which remain closed in this FMP. As

shown on Table 4.5-49, about 43 percent of the fishable area in the Aleutians is closed to bottom trawling at one time or another during the year under this FMP. Less than one percent of the deep area is closed to bottom trawling. Figures 4.6-1 and 4.6-2 show the closure areas under FMP 2.1 broken down by gear type, bottom trawl, and fixed gear. As seen on the figures, closure areas in the Aleutians are the same as those shown and discussed for FMP 1 and the baseline. As such, there is little diversity in protection. The Aleutian Islands bathymetry and habitat is distributed on a fine scale, with fishing effort that is patchy and in small clusters. Based on these observations as relative to the baseline, the predicted effects of FMP 2.1 on benthic community diversity are considered conditionally significantly adverse due to the predicted increase in concentrated fishing effort. The geographic diversity of impacts are considered insignificant due to the similarity in closed areas under the baseline condition.

- **GOA.** As shown on Table 4.5-49 and Figures 4.6-1 and 4.6-2, FMP 2.1 closes nearly 22 percent of the fishable area in the GOA to trawling at one time or another during the year. However, the FMP eliminates the baseline closed area that was adjacent to an area of intermediate fishing intensity, which provided some diversity of impact in habitat found along the boundary. Therefore, the predicted effect of FMP 2.1 on benthic community diversity is significantly adverse relative to the existing baseline due to the opening of these closed areas. The predicted effects of FMP 2.1 on geographic diversity of impacts is conditionally significant adverse, also due to the opening of these closed areas.

Cumulative Effects of FMP 2.1

Cumulative effects on habitat for FMP 2.1 are summarized on Table 4.5-50. The following discussion of cumulative effects as presented on the table is broken down by geographic area.

Bering Sea

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in a significantly adverse change from baseline conditions, and, as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Bering Sea. Mortality of species such as tree corals and other sessile epifauna is likely to be persistent in these areas. The areas historically and recently closed to fishing described in Section 3.6 may be recovered or recovering with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, and marine pollution all have the potential to cause direct mortality of benthic organisms and changes to living habitat. Offal discharge can occur from offshore catcher processors and onshore processors. However, impacts that include mortality due to smothering and reduced oxygen are expected to be more prevalent in inshore, closed bay locations. Improvements in offal pre-treatment and discharge regulations in recent years have reduced impacts and potentially improved conditions. Port expansion and increased use are possible at several locations in the Bering Sea area, including Port Moller, Port Heiden, Dillingham, St. Paul and St. George. Again, the impacts include mortality

due to smothering and/or burying, would only affect nearshore zones and bays. Marine pollution is also identified as having a reasonably foreseeable, potentially adverse effect since acute and/or chronic pollution events, if large enough in scale, could cause mortality to benthic organisms. Again, areas most likely to be impacted would be nearer to shore. Natural events such as storm surges and waves also have the potential to cause direct morality through burial. These effects, like the others, would be expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organisms.

- **Cumulative Effects.** Cumulative effects on mortality of Bering Sea benthic organisms are judged to be significantly adverse under FMP 2.1. Additional external factors would not improve conditions and could add to the mortality of benthic organisms.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in a significantly adverse change from baseline conditions, and, as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Bering Sea. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may be recovered or recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, and marine pollution all have the potential to cause changes to benthic community structure. If the effect is long-term, as in the case of changes in weather patterns, wind-induced waves and surges could also cause sufficient changes to the substrate such that the benthic community is impacted. As discussed under changes to living habitat, all of these impacts are more likely to be observed in nearshore areas. Regime shifts, and large-scale environmental fluctuations associated with ENSO and La Nina events have been identified as having impacts on both the physical and biological systems in the North Pacific. These changes could have either beneficial or adverse effects on the benthic community (see Sections 3.6 and 3.10).

- **Cumulative Effects.** Cumulative effects on benthic community structure of the Bering Sea are judged to be significantly adverse under FMP 2.1. Additional external factors would not improve conditions, and could add to adverse changes in the benthic community.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described previously in Section 4.6.6 this effect is judged to result in a conditionally significant adverse change from baseline conditions, and as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected since fishing effort and distribution have changed over time as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 illustrate the spatial

measures that were in effect before 1980 or were later established by regulations following publication of the Final Groundfish SEIS in November of 1980. As discussed in Section 3.6, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most of the restricted areas were implemented to spatially and temporarily restrict the foreign fishery. This was done to prevent conflicts between domestic and foreign fisheries over bycatch of species important to U.S. fishermen or grounds preemption and gear conflicts. Most domestic fishing effort focused on crab, salmon, and herring. Figures 3.6-6 and 3.6-7 illustrate that, in 1980, there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries. This was due to the need to give priority to the domestic fisheries that used similar gear and fishing grounds. Table 4.5-51 shows that in 1980 almost 9 percent of the fishable area in the Bering Sea was closed to trawling, with 2.2 percent closed to all fishing. There were no longline-only closures in the Bering Sea at that time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion, and marine pollution all have the potential to change geographic diversity and impacts protection. As existing ports in the Bering Sea are expanded and new ports created, additional dock space for harboring the fishing fleet is made available. While the fleet might not necessarily expand, the opening of new ports may allow vessels of all sizes to access new or relatively unfished areas. On the other hand, depending on distribution, fishing pressure in heavily fished areas may be eased as access to other areas becomes available. Closed areas proposed to continue under this FMP would not be affected by the redistribution of home ports. Depending on the distribution of fishing effort, previously un-impacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects**. Cumulative effects on changes in distribution of fishing effort are judged to be conditionally significant adverse. The maps and statistics discussed under persistent past effects show that FMP 2.1 would protect slightly less benthic habitat from trawl gear in the future (7.6 percent) than was protected in 1980 (8.6 percent). This FMP opens many crab and halibut habitat protection areas that are presently closed. Additional external effects are not expected to improve the internal FMP rating.

Aleutian Islands

<u>Changes to Living Habitat – Direct Mortality of Benthic Organisms</u>

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in a significantly adverse change from baseline conditions, and, as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected in heavily fished areas of the Aleutian Islands. Prevalence of long-lived species of coral makes impacts a particular concern in the Aleutians. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas. However, mobile epibenthic predators are not likely to exhibit lingering effects since they can move into non-fished areas (see Section 3.6). The areas historically and recently closed to fishing described in Section 3.6 may be recovered or recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, and marine pollution all have the potential to cause direct mortality of benthic organisms and changes to living habitat. Dredging for scallop fisheries and/or navigation can occur in localized areas (often in conjunction with port development) and can cause burial or smothering of benthic fauna. Damage to living substrates by longline and pot fisheries (see Section 3.6) has been documented and is expected to continue in those heavily fished areas. Offal discharge can occur from offshore catcher processors and onshore processors, causing mortality in nearshore areas. However, improvements in offal pre-treatment and discharge regulations in recent years have reduced impacts and potentially improved conditions. Port expansion and increased use is possible at several locations in the Aleutian Islands including Atkutan, Adak, Unalaska, Cold Bay Dutch Harbor, and King Cove. Again, the impacts include mortality due to smothering and/or burying, and would only affect nearshore zones and bays. Marine pollution is also identified as having a reasonably foreseeable potentially adverse impact since acute and/or chronic pollution events, if large enough in scale, could cause mortality to benthic organisms. Natural events, such as storm surges and waves, also have the potential to cause direct morality through burial. These effects, like the others, would be expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organisms.

- **Cumulative Effects.** Cumulative effects on mortality of Aleutian Islands benthic organisms are judged to be significantly adverse. Additional external factors would not improve conditions, and could add to the mortality of benthic organisms.

<u>Changes to Benthic Community Structure</u>

- **Direct/Indirect Effects.** As described above in previously in 4.6.6, this effect is judged to result in a significantly adverse change from baseline conditions, and, as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected in heavily fished areas of the Aleutians. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may be recovered or recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline and pot fisheries, offal discharge, port expansion and use, and marine pollution all have the potential to cause changes to benthic communities. If the effects is long-term, as in the case of changes to weather patterns, wind induced waves and surges could also cause sufficient changes to the substrate such that the benthic community is impacted. As discussed under changes to living habitat, all of these impacts are more likely to be observed in nearshore areas. Regime shifts and large-scale environmental fluctuations associated with ENSO and La Nina events have been identified as having impacts on both the physical and biological systems in the North Pacific (see Sections 3.6 and 3.10). These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects.** Cumulative effects on in benthic community structure of the Aleutians are judged to be significantly adverse. Additional external factors would not improve conditions, and could add to adverse changes in the benthic community.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described above in Section 4.6.6, this effect is judged to result in an insignificant change to the baseline, and as described in Section 3.6 the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected since fishing effort and distribution have changed over time as areas have been closed and remain closed. As discussed previously for the Bering Sea, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species; most domestic fishing effort focused on crab, salmon, and herring. Figures 3.6-6 and 3.6-7 illustrate that, back in 1980, there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries, in order to give priority to the domestic fisheries that used similar gear and fishing grounds. Table 4.5-51 shows that in 1980 about 31 percent of the fishable area in the Aleutians was closed to trawling with about 6 percent closed to all fishing. There were no longline-only closures in the Aleutian Islands at that time.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future external effects include other fisheries, port expansion and the potential resultant changes to offal discharge, and marine pollution episodes. Depending on changes in distribution of fishing effort, sensitive areas could either be additionally impacted or allowed to recover. As with the Bering Sea, existing ports in the Aleutians will be expanded and new ports created, and additional dock space for harboring the fishing fleet will be made available. While the fleet might not necessarily expand, the distribution of fishing effort is likely to change, and previously unimpacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects.** Cumulative effects on changes in distribution of fishing effort are judged to be conditionally significant adverse. The maps and statistics discussed above under persistent past effects show that FMP 2.1 would protect more benthic habitat from trawl gear in the future (43 percent) than was protected in 1980 (31 percent). However, the spatial distribution of the closed areas under the current FMPs may not protect the full range of habitat types. Additional external impacts do not provide any protection and could add to lingering past mortality impacts and to impacts that are already evident. This is particularly important since FMP 2.1 does not require a reduction in TAC. The benefits provided by the closed areas are uncertain since previously unfished areas would likely be fished, and impacts would occur in areas not previously impacted.

GOA

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in a significantly adverse change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected in heavily fished areas of the GOA. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas. The areas historically and recently closed to fishing described in Section 3.6 may be recovered or recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** As described for the BSAI, dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, and marine pollution all have the potential to cause direct mortality of benthic organisms and changes to living habitat. Port expansion and increased use is possible at several locations in the GOA, including Kodiak, Sand Point, Chignik, Port Lions, Ouzinkie, Valdez, and Seward. Impacts include mortality due to smothering and/or burying, and would likely only affect nearshore zones and bays. Marine pollution is also identified as having a reasonably foreseeable potentially adverse effect since acute and/or chronic pollution events, if large enough in scale, could cause mortality to benthic organisms. Natural events, such as storm surges and waves, also have the potential to cause direct morality through burial. These effects, like the others, would be expected in shallow waters where the wave energy is transmitted to the bottom without much attenuation through the water column. Climate changes and regime shifts are not expected to cause direct mortality of benthic organism.

- **Cumulative Effects.** Cumulative effects on mortality of GOA benthic organisms are judged to be significantly adverse. The additional external factors would not improve conditions, and could add to the mortality of benthic organisms.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in a significantly adverse change from baseline conditions, and, as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected in heavily fished areas of the GOA. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may be recovered or recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** As with the other regions, dredging, longline and pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events all have the potential to cause changes to GOA benthic communities. These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects.** Cumulative effects on changes in benthic community structure of the GOA are judged to be significantly adverse. The additional external factors would not improve conditions, and could add to adverse changes in the benthic community.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in a conditionally significant adverse change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected since fishing effort and distribution have changed over time as areas have been closed and remain closed. As discussed for the other regions, during the late 1970s and early 1980s, there was little domestic fishing for groundfish species. Most domestic fishing effort focused on crab, salmon, and herring, and there were more restrictions placed on foreign fixed gear fisheries than trawl fisheries (Figures 3.6-6 and 3.6-7). Table 4.5-51 shows that in 1980 about 5 percent of the fishable area in the GOA was closed to trawling, with about 7 percent closed to all fishing. The largest closures in the GOA were for longline fishing, where almost 61 percent of the fishable area was closed to longlining. Therefore in 1980, about 73 percent of the fishable area in the GOA was closed to fishing of one type or another sometime during the year.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future external effects include other fisheries, port expansion and the potential resultant changes to offal discharge, and marine pollution. Depending on changes in distribution of fishing effort, sensitive areas could either be additionally impacted or allowed to recover. As existing ports in the GOA are expanded and new ports created, additional dock space for harboring the fishing fleet is made available, and changes in the distribution of fishing effort could result. Depending on the distribution of fishing effort, previously unimpacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case. Closed areas proposed to continue under this FMP would not be affected by the redistribution of home ports.

- **Cumulative Effects.** Cumulative effects on changes in distribution of fishing effort are judged to be conditionally significant adverse. The maps and statistics discussed under persistent past effects show that FMP 2.1 would protect more benthic habitat from trawl gear in the future (22 percent) than was protected in 1980 (16 percent). However, the spatial distribution of the closed areas under FMP 2.1 may not protect the full range of habitat types and crab and halibut habitat protection areas that are presently closed would be opened under this scenario. Also, in 1980 more benthic habitat was protected from fixed gear (over 60 percent of the fishable area) than would be protected under FMP 2.1 (<1 percent of the fishable area in the GOA). While fixed gear impacts are believed to cause less of an impact on benthic communities, research has shown that considerable bycatch of coral and other large benthic structures occur with this gear type. Therefore, the additional past and external effects are not expected to improve the internal FMP rating.

Direct/Indirect Effects of FMP 2.2

Example FMP 2.2 is identical to FMP 1 for habitat impacts. Figure 4.2-3 (bookend) illustrates the suite of year-round closures in the BSAI and GOA management areas.

Direct and indirect effects of FMP 2.2 on habitat are discussed for changes to living habitat through direct mortality or benthic organisms and changes to benthic community structure through benthic community

diversity and geographic diversity of impacts and protection. Due to their differences in habitat type, the BSAI and GOA are rated and discussed separately.

Changes to Living Habitat – Direct Mortality of Benthic Organisms

In the GOA, the multi-species model results indicate that catch of most living habitats will decline under FMP 2.2. (Table 4.5-48). In the BSAI, bycatch levels are predicted to be within approximately 20 percent of the baseline. The model projections for the GOA are unrealistically low relative to the baseline. This is because the model framework artificially constrained specific fisheries, such as rockfish, that historically have had a high bycatch rate of living substrates (Jim Ianelli, AFSC, personal communication 2003). Based on past performance, it is doubtful that such constraints will severely curtail the rockfish fishery. . Therefore, a more realistic prediction is that bycatch levels would be about the same as the baseline.

The habitat impacts model predicts the following effects for FMP 2.2 on biostructure relative to the baseline:

- **Bering Sea.** There is no predictable difference in impacts to habitat between FMP 2.2 and baseline conditions. For both, mean impacts are low when averaged over the entire fishable EEZ; impacts to biostructure ranged from 1.8 to 9.3 percent of the fishable EEZ and from 8.2 to 41.9 percent of the fished area. A large area in the Bering Sea (8,000 sq mi) that is subject to high fishing intensity potentially causes an 83 percent reduction in equilibrium biostructure level when a 15 year recovery rate is modeled. Based on these results, we conclude that there would be an insignificant change to mortality and damage to living habitat as a result of FMP 2.2.

- **Aleutian Islands.** There is no predictable difference in impacts to habitat between FMP 2.2 and from baseline conditions. For both, meaan impacts ranged from 1.1 to 6.8 percent of the fishable EEZ and from 5.4 to 32.6 percent of the fished areas. Therefore, we rate the change resulting from FMP 2.2 relative to the baseline as insignificant. However, prevalence of long-lived species of coral in the bycatch is a particular concern in the Aleutian Islands under FMP 2.2. With a recovery rate for red tree coral possibly as low as $\rho = 0.005$ (200 years) and sensitivity $q_H = 0.27$, the habitat impact model indicates that fishing intensity as low as $f = 0.10$ (total area swept once every 10 years) results in an equilibrium level reduction of 85 percent relative to the unfished level. About 9 percent of the area (3,590 sq mi) is estimated to be fished at $f = 0.10$ or greater. Thus, continued bycatch and damage to living habitat at FMP 2.2 bycatch levels may have negative consequences on habitat quality.

- **GOA.** There is no predictable difference in impacts too habitat between FMP 2.2 and baseline conditions. For both, mean impact on biostructure ranged from 0.9 to 6.9 percent of the fishable EEZ and from 3.8 to 29.0 percent of the fished areas. Only 2 percent of the fishable EEZ (2,418 sq mi) is potentially impacted to below 32 percent of unfished levels when a 15 year recovery rate is used. Therefore, for FMP 2.2, we rate this change in mortality and damage to living habitat as insignificant.

Changes to Benthic Community Structure – Benthic Community Diversity and Geographic Diversity of Impacts and Protection

- **Bering Sea.** Identical to the baseline and FMP 1, FMP 2.2 closures in the Bering Sea are mostly concentrated on sand substrate (Table 4.5-47). Only 27 percent of the geographical habitat zones

have at least 20 percent of their area closed to bottom trawling. Figure 4.1-10 shows that the amount of large contiguous areas of high fishing intensity—that is, areas that are swept at least once each year with bottom trawls—exceeds 8,000 sq mi (Table 4.1-26). Table 4.5-49 shows that, of the Bering Sea fishable area, 19.3 percent is closed to bottom trawling under FMP 2.2. However, very little geographic diversity of fishing impacts occurs within the closed habitats because the closed areas do not represent diverse closures of habitat (i.e., they are concentrated on sand substrate). In addition, very few of the closures are year-round. Figure 4.5-4 shows areas closed to trawling only at various times of the year under this FMP, while Figure 4.5-5 depicts just those areas closed to fixed gear only.

Application of the habitat impacts model indicated that, depending on plausible sensitivity and recovery parameters, fishing of this intensity could reduce the amount of biostructure in the area by 13 to 75 percent of its unfished equilibrium level (Table 4.5-48). Such biostructure includes sponges, soft corals, tunicates, and anemones (Heifetz 2002, Malecha *et al.* 2003). There are no existing closure areas adjacent to these intensely fished areas to provide a diverse level of impact. While existing closures tend to be large and cover all of a particular habitat, they provide little diversity in fishing impacts. The primary focus of these past regulations has been to prevent potential damage to vulnerable crab habitat from bottom trawl gear; therefore, the closures do not necessarily cross a wide range of habitat types. Some of the trawl closures are in effect year-round while others are seasonal (see Section 3.6). Compared to the existing baseline, the predicted effects of FMP 2.2 on benthic community diversity is insignificant. Similarly, the predicted effects of FMP 2.2 on geographic diversity of impacts is also predicted to be insignificant.

- **Aleutian Islands.** Identical to the baseline and FMP 1, FMP 2.2 closures in the Aleutian Islands are concentrated in shallow water, where only 4 percent of the area is closed to bottom trawling year-round for all species. However, as shown on Table 4.5-49, about 43 percent of the fishable area in the Aleutians is closed to bottom trawling at one time or another during the year under FMP 2.2. These closures are associated with sea lion rookeries. As in the baseline, there is very little diversity in protection. Less than one percent of the deep area is closed to bottom trawling. Figure 4.1-10 shows that none of the closure areas extend over any blocks of significant fishing effort. Figures 4.5-4 and 4.5-5 show the closure areas under FMP 2.2 broken down by gear type, bottom trawl and fixed gear, respectively. The Aleutian Islands bathymetry and habitat is distributed on a fine scale, with fishing effort that is patchy and in small clusters. Based on these observations relative to the baseline, the predicted effects of FMP 2.2 on benthic community diversity and geographic diversity of impacts are insignificant.

- **GOA.** Figure 4.5-6 shows that, as in the baseline, minimal geographic diversity of impact or protection results from the current suite of closed areas. Except for the southeast trawl closure, which covers several entire habitat types, all other closures are inshore (see Figure 4.5-6). As shown on Table 4.5-49 and Figures 4.5-4 and 4.5-5, FMP 2.2 closes nearly 46 percent of the fishable area in the GOA to trawling at one time or another during the year. The inshore closure areas tend to be large relative to the size of bathymetric and habitat resolution scale and thus tend to encompass a large portion of a bathymetric feature. Based on these results, the predicted effect of FMP 2.2 on benthic community diversity and geographic diversity of impacts is insignificant.

Cumulative Effects of FMP 2.2

Cumulative effects on habitat for FMP 2.2 are summarized on Table 4.5-50. The following discussion of the cumulative effects as presented on the table is broken down by geographic area.

Bering Sea

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Bering Sea. These effects include persistent mortality of long-lived species such as tree corals and other sessile epifauna (see the cumulative effects discussion for FMP 2.1).

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, marine pollution, and natural events all have the potential to cause direct mortality of benthic organisms and changes to living habitat (see the cumulative effects discussion for FMP 2.1).

- **Cumulative Effects.** Cumulative effects on mortality of Bering Sea benthic organisms are judged to be conditionally significant adverse. Additional external impacts will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though FMP 2.2 is rated as insignificant, bycatch and damage to living habitat in the Bering Sea will continue to negatively impact benthic living habitat.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Bering Sea. (See the cumulative effects discussion for FMP 2.1 for additional information.) Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6 for discussion and references). However, the areas historically and recently closed to fishing described in Section 3.6 may be recovered or recovering, with past mortality effects becoming less evident over time.

- **Reasonably Foreseeable Future External Effects.** Offal discharge, port expansion and use, marine pollution, and natural events all have the potential to cause changes to benthic communities as described for FMP 2.1. These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects.** Cumulative effects on changes in benthic community structure of the Bering Sea are judged to be conditionally significant adverse. Additional external impacts described above

will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though FMP 2.2 is rated as insignificant, bycatch and damage to living habitat in the Bering Sea will continue to negatively impact benthic living habitat.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected since fishing effort and distribution has changed over time as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 and Table 4.5-51 show that in 1980 almost 9 percent of the fishable area in the Bering Sea was closed to trawling, with 2.2 percent closed to all fishing. The cumulative effects section for FMP 2.1 provides additional discussion regarding past effects.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future external effects include port expansion and the potential resultant changes to fishing effort, offal discharge, and marine pollution episodes (see discussion for FMP 2.1). Depending on the distribution of fishing effort, previously unimpacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects.** Cumulative effects on changes in distribution of fishing effort are judged to be conditionally significant adverse. The maps and statistics discussed under persistent past effects show that FMP 2.2 would protect more benthic habitat from trawl gear in the future (19 percent) than was protected in 1980 (8.6 percent). However, the spatial distribution of the closed areas under FMP 2.2 will not protect the full range of habitat types, or provide for a diversity of impacts within fished areas. Existing closures tend to be large and cover all of a particular habitat, and they provide little diversity in fishing impacts since the primary focus of past regulations has been to prevent potential damage to vulnerable crab habitat from bottom trawl gear (see Direct/Indirect Effects discussion and baseline description in Section 3.6). Additional external impacts do not provide any protection and could add to the lingering past mortality impacts and to impacts that are already evident. This is particularly important since FMP 2.2 does not require a reduction in TAC. The benefits provided by the closed areas are uncertain since previously unfished areas would likely be fished, and impacts would occur in areas not previously impacted.

Aleutian Islands

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Aleutian Islands. Prevalence of long-lived species of coral makes impacts a particular concern in the Aleutians. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to

be persistent in these areas. See the FMP 2.1 cumulative effects discussion for additional information on these impacts.

- **Reasonably Foreseeable Future External Effects.** Dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events all have the potential to cause direct mortality of benthic organisms and changes to living habitat. See the FMP 2.1 discussion of cumulative impacts in the Aleutian Islands for additional details.

- **Cumulative Effects.** Cumulative effects on mortality of Aleutian Islands benthic organisms are judged to be conditionally significant adverse. Long-lived species, such as tree coral, are more prevalent in the Aleutian Islands. Additional external impacts will add to lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though FMP 2.2 is rated as insignificant, bycatch and damage to living habitat will continue to negatively impact benthic living habitat in the Aleutian Islands.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the Aleutians. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1, dredging, longline and pot fisheries, offal discharge, port expansion and use, natural events, and marine pollution all have the potential to cause changes to benthic communities. These changes could have either beneficial or adverse effects on the benthic community.

- **Cumulative Effects.** Cumulative effects on changes in benthic community structure of the Aleutians are judged to be conditionally significant adverse. Additional external impacts will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though the direct/indirect effects of FMP 2.2 are rated as insignificant, continued bycatch and damage to living habitat will increase negative impacts on the benthic community.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected since fishing effort and distribution has changed over time as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 and Table 4.5-51 show that in 1980 about 31 percent of the fishable area in the Aleutians was closed to trawling, with about 6 percent closed to all fishing. There were no longline-only closures in the

Aleutian Islands at that time. The cumulative effects section for FMP 2.1 provides additional discussion regarding these past effects.

- **Reasonably Foreseeable Future External Effects** include other fisheries, port expansion and the potential resultant changes to fishing effort, offal discharge, and marine pollution episodes. See the discussion for cumulative effects of FMP 2.1 for additional details.

- **Cumulative Effects.** Cumulative effects on changes in distribution of fishing effort are judged conditionally significant adverse. The maps and statistics discussed udner persistent past effects show that FMP 2.2 would protect more benthic habitat from trawl gear in the future (43 percent) than was protected in 1980 (31 percent). However, the spatial distribution of the closed areas under the current FMPs may not protect the full range of habitat types.

GOA

Changes to Living Habitat – Direct Mortality of Benthic Organisms

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, and as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the GOA. Mortality of long-lived species such as tree corals and other sessile epifauna is likely to be persistent in these areas (see discussion for FMP 2.1).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1 cumulative effects, dredging, longline fisheries, pot fisheries, offal discharge, port expansion and use, marine pollution, and natural events all have the potential to cause direct mortality of benthic organisms and changes to living habitat.

- **Cumulative Effects.** Cumulative effects on mortality of GOA benthic organisms are judged to be conditionally significant adverse. Additional external impacts will add to the lingering past mortality impacts and contribute to impacts that are already evident. Thus, even though the direct/indirect effects of FMP 2.2 are rated as insignificant, bycatch and damage to living habitat will continue in the GOA and will negatively impact benthic living habitat.

Changes to Benthic Community Structure

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, but as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Persistent past effects are expected in heavily fished areas of the GOA. Changes to benthic community structure, including a reduction in species diversity, have been observed in heavily fished areas of the world (see Section 3.6).

- **Reasonably Foreseeable Future External Effects.** As described for FMP 2.1 in the GOA, dredging, longline and pot fisheries, offal discharge, port expansion and use, natural events, and marine pollution all have the potential to cause changes to benthic communities. These changes could have either beneficial or adverse effects on the community.

- **Cumulative Effects.** Cumulative effects on changes in benthic community structure of the GOA are judged to be conditionally significant adverse. Additional external impacts will add to the lingering past impacts and contribute to impacts that are already evident. Thus, even though the direct/indirect effects of FMP 2.2 are rated as insignificant, bycatch and damage to living habitat in the GOA will continue to negatively impact the benthic community.

Geographic Diversity of Impacts and Protection

- **Direct/Indirect Effects.** As described previously in Section 4.6.6, this effect is judged to result in an insignificant change from baseline conditions, but as described in Section 3.6, the baseline is considered to be already adversely impacted.

- **Persistent Past Effects.** Past effects are expected since fishing effort and distribution has changed over time as areas have been closed and remain closed. Figures 3.6-6 and 3.6-7 and Table 4.5-51 show that in 1980 about 5 percent of the fishable area in the GOA was closed to trawling, with about 7 percent closed to all fishing. The largest closures in the GOA were for longline fishing, where almost 61 percent of the fishable area was closed to longlining. Therefore, in 1980, about 73 percent of the fishable area in the GOA was closed to fishing of one type or another at some time during the year (see discussion for FMP 2.1).

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future external effects include other fisheries, port expansion and the potential resultant changes to fishing effort, offal discharge, and marine pollution episodes (see the FMP 2.1 cumulative effects discussion for the GOA). Depending on the distribution of fishing effort, previously unimpacted areas could be impacted by offal discharge and marine pollution. Natural events are not expected to be contributing factors in this case.

- **Cumulative Effects.** Cumulative effects on changes in distribution of fishing effort are judged conditionally significant adverse. The maps and statistics discussed under persistent past effects show that FMP 2.2 would protect much more benthic habitat from trawl gear in the future (46 percent) than was protected in 1980 (16 percent). However, the spatial distribution of the closed areas under the FMP 2.2 may not protect the full range of habitat types. Also, in 1980 more benthic habitat was protected from fixed gear (over 60 percent of the fishable area) than would be protected under FMP 2.2 (<1 percent of the fishable area in the GOA). While fixed gear impacts are believed to cause less of an impact on benthic communities, research has shown that considerable bycatch of coral and other large benthic structures occur with this gear type. The additional external impacts will add to the lingering impacts and contribute to impacts that are already evident.

4.6.7 Seabirds Alternative 2 Analysis

4.6.7.1 Short-Tailed Albatross

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Incidental Take

The seabird protection measures for longline vessels under FMP 2.1 and FMP 2.2 would be the same as those that exist under the baseline conditions unless the USFWS requires a change in regulations under Section 7 of the ESA to protect the short-tailed albatross. For this analysis, it is assumed that the regulations will remain in effect as they were in 2002 (Section 3.7.1). Statistical analysis of the effectiveness of the baseline regulations in preventing incidental take of short-tailed albatross on longlines is problematic given the rarity of encounters. The issue would be even more difficult to resolve if observer coverage of fishing effort was decreased as proposed in FMP 2.1. It is clear, however, that the existing regulations have not eliminated the incidental take of short-tailed albatross. The fact that two short-tailed albatross were caught in one month in 1998 by vessels that were technically in compliance with the regulations indicates that the threat remains. The lack of performance standards in the existing regulations is considered a major limitation in the overall effectiveness of the techniques. Although education programs for fishermen in proper deployment methods could improve this situation, FMP 2.1 defines a very "hands-off" approach to fishery management where such training programs would be unlikely to occur. Using information from the projection model on Pacific cod TAC and qualitative assumptions about gear allocation within a basically unregulated fishery, the longline fishing effort in the BSAI under FMP 2.1 is predicted to be similar to the baseline longline effort, despite a major increase in overall groundfish harvest.

Longline effort in the GOA is predicted to almost double from the baseline effort under FMP 2.1. However, the baseline effort in the GOA is about seven times less than in the BSAI, and accounts for almost 20 times fewer birds taken incidentally. For these reasons, FMP 2.1 is considered to present the same or slightly increased risk of incidental take of short-tailed albatross on longlines as the baseline condition. Under FMP 2.2, longline effort is predicted to be about the same as under the baseline condition. The risk of incidental take of short-tailed albatross on longlines would therefore continue at the estimated rate of two birds per year under both FMP 2.1 and FMP 2.2; a rate that does not jeopardize the existence of the species but may slow its recovery (USFWS 1997).

There are presently no regulations that require any mitigation of seabird incidental take in either the trawl or pot sectors of the groundfish fleet, and no restrictions on these sectors would be implemented under FMP 2.1 or 2.2. Although no short-tailed albatross have been observed or reported to be taken in groundfish trawl gear, Laysan albatross are known to be taken in trawls, so the potential for taking the similar short-tailed albatross exists. In addition, NOAA Fisheries and USFWS are currently investigating whether collisions with trawl third wires pose a threat to short-tailed albatross, as these wires are known to cause mortality of other albatross. The level of bottom and pelagic trawl effort under FMP 2.1 is predicted to increase by 200 to 300 percent in the BSAI and remain about the same in the GOA (although there would be a shift of effort from bottom trawls to pelagic trawls). If the amount of trawl effort is directly proportional to the risk of taking albatross either in trawl gear or through vessel strikes, an assumption that has not yet been tested, this substantial increase in trawl effort under FMP 2.1 could pose an increased risk of taking short-tailed albatross. Such a change in the nature of the fishery would likely prompt a new Section 7 consultation with the USFWS. If USFWS determines that the trawl sector is likely to cause mortality of this endangered

species, in addition to the mortality that is assumed and observed to occur in the longline fisheries, the combined incidental take in the groundfish fisheries could exceed the mortality threshold of four birds per two year period that was established in the last BiOp (USFWS 1997) and would likely be considered significant at the population level. Given the conjectural nature of these conditions occurring, FMP 2.1 is considered to be conditionally significant adverse for incidental take of short-tailed albatross from the groundfish fishery.

Under FMP 2.2, trawl effort is expected to increase by approximately 25 percent over the baseline condition. As with all matters concerning fishery interactions with this endangered species, the USFWS would have the responsibility under Section 7 of the ESA to review the proposed structure of the fishery and determine if the changes pose a significant risk to the continued existence of the species. While the outcome of those complex deliberations cannot be predicted at this time, it will be assumed that the modest increase in trawl effort proposed under FMP 2.2 would not be considered a substantial increase in risk for incidental take of the species. FMP 2.2 would therefore be considered to have insignificant effects on short-tailed albatross through incidental take.

Change in Food Availability

Short-tailed albatross forage over vast areas of ocean and are therefore unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 2.1 or 2.2, even if a directed forage fish fishery was developed. FMP 2.1 and FMP 2.2 are therefore considered to have insignificant effects on short-tailed albatross through availability of food.

Benthic Habitat

Short-tailed albatross are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 2.1 or FMP 2.2. FMP 2.1 and FMP 2.2 are therefore considered to have no effects on short-tailed albatross through benthic habitat.

Cumulative Effects of FMP 2.1 and FMP 2.2

The past/present effects on short-tailed albatross are described in Section 3.7.4 (Table 3.7-12) and the predicted direct and indirect effects of the groundfish fishery under FMP 2.1 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for this species would be dominated by factors external to the groundfish fisheries and are summarized below.

Mortality

- **Direct/Indirect Effects.** Under FMP 2.1, the risk of incidental take on longlines would be about the same or slightly greater than the baseline conditions. Risk of incidental take on trawl gear, however, would increase substantially. The overall risk of incidental take of short-tailed albatross is therefore considered conditionally significant adverse under FMP 2.1. Under FMP 2.2, the risk of incidental take would be the same or negligibly higher than the baseline conditions. Therefore, the overall risk of incidental take of short-tailed albatross is considered insignificant under FMP 2.2.

- **Persistent Past Effects.** The most important persistent influence on the short-tailed albatross population is their near extinction due to commercial feather hunting. Conservation efforts have allowed the population to recover at or near to its biologically maximum rate. The total fishery-related mortality of short-tailed albatross is unknown but it does not appear to be having an overriding effect on the population growth rate.

- **Reasonably Foreseeable Future External Effects.** The short-tailed albatross population may be substantially affected by several natural and human-caused mortality factors that may or may not occur in the future, including volcanic eruptions on their main breeding site, Torishima Island, and increased rates of incidental take in fisheries throughout their range. If the species experiences a substantial increase in mortality that threatens its recovery, it may lead to further efforts to protect the species from fishery interactions.

- **Cumulative Effects.** Since the population of short-tailed albatross is susceptible to several natural and human-caused mortality factors that may or may not occur in the future, including incidental take in the groundfish fisheries, the cumulative effect on short-tailed albatross is considered to be conditionally significant adverse at the population level through mortality for FMP 2.1 and FMP 2.2..

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a very small amount of squid and forage fish as bycatch under FMP 2.1 and FMP 2.2 and an unknown amount of forage fish under a potential directed fishery. This effect is considered insignificant at the population level for short-tailed albatross.

- **Persistent Past Effects.** Short-tailed albatross primarily prey on squid and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to natural fluctuations in primary productivity and oceanographic factors. Pollution from a variety of land and marine sources have potentially affected short-tailed albatross prey in the past but specific toxicological effects are unknown.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on short-tailed albatross prey availability. Pollution is likely to affect short-tailed albatross prey in the future but specific predictions on the nature and scope of the effects, especially as they relate to the availability of prey to short-tailed albatross, can not be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of short-tailed albatross prey is considered to be insignificant at the population level.

Benthic Habitat

Since short-tailed albatross feed at the surface and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have

no discernable effect on their prey. Therefore, no cumulative effect on benthic habitat is identified for short-tailed albatross.

4.6.7.2 Laysan Albatross and Black-Footed Albatross

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Incidental Take

As described in Section 4.6.7.1, longline effort in the BSAI is expected to be about the same as under the baseline condition and is expected to almost double in the GOA under FMP 2.1. Incidental take of albatross on longlines is therefore expected to be the same as the baseline condition in the BSAI. Since there is not a strong correlation between fishing effort and incidental take of any species besides fulmars, the increased longline effort in the GOA may translate into similar or slightly increased levels of albatross take as the baseline condition. These levels of incidental take are considered insignificant at the population level for both species (see Section 4.5.7.2). FMP 2.1 is also expected to increase incidental take in trawl gear and vessel strikes due to a major increase in trawl effort. It is not known whether there is a direct proportional relationship between trawl effort and incidental take of albatross. However, if we assume that take levels would increase 300 percent in direct response to the increased level of trawl effort, take of Laysan albatross in trawls would average about 270 birds per year (Table 3.7-4, using the mean of low and high estimates). No black-footed albatross have been recorded as being taken in the combined trawl fisheries. Combining the expected increase in trawl mortality with the baseline level of longline take, the expected total take of Laysan albatross under FMP 2.1 would average approximately 1050 birds per year. This would represent an estimated 0.04 percent of their population (2.4 million birds) and is therefore considered insignificant on the population level. FMP 2.1 is therefore considered to have insignificant effects on both albatross species through overall incidental take.

Under FMP 2.2, the seabird protection measures, and level of effort for longline vessels would be the same as under the baseline condition. The predicted level of incidental take of both albatross species on longlines would therefore approximate the baseline levels described in Section 4.5.7.2, which are considered insignificant at the population level. Trawl effort is expected to increase under FMP 2.2 by approximately 25 percent over the baseline condition. If it is assumed that this increase in effort will result in a corresponding increase in incidental take, take of Laysan albatross in trawls would average about 112 birds per year (Table 3.7-4, using the mean of low and high estimates). This level of take is very small relative to the abundance of this species and is therefore considered to be insignificant at the population level. The overall effect of FMP 2.2 on both albatross species is therefore considered to be insignificant through incidental take.

Changes in Food Availability

Albatross forage over vast areas of ocean and are therefore unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 2.1 or 2.2, even if a directed forage fish fishery develops. FMP 2.1 and FMP 2.2 are therefore considered to have insignificant effects on these species through availability of food.

Benthic Habitat

Albatross are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 2.1 or FMP 2.2. FMP 2.1 and FMP 2.2 are therefore considered to have no effects on these species through benthic habitat.

Cumulative Effects of FMP 2.1 and FMP 2.2

The past/present effects on these albatross species are described in Sections 3.7.2 and 3.7.3 (Tables 3.7-6 and 3.7-7) and the predicted direct and indirect effects of the groundfish fishery under FMP 2.1 and FMP 2.2 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for these species would be dominated by factors external to the groundfish fisheries and would be the same as those described in Section 4.5.7.2 (Table 4.5-53) and summarized below.

Mortality

- **Direct/Indirect Effects.** Under this alternative, the same seabird protection measures that are described in the baseline conditions (see Section 3.7.1) would be maintained. The predicted level of incidental take from all gear types is considered insignificant at the population level for both albatross species.

- **Persistent Past Effects.** For black-footed and Laysan albatross, past mortality factors include large contributions from foreign longline fisheries and Hawaiian pelagic longline fisheries, a smaller contribution from the BSAI/GOA longline fisheries, and an unknown contribution from other longline fisheries, trawl fisheries, and vessel collisions throughout their range. Both species have been experiencing population declines over the past decade. The contribution of toxic and plastic pollution on their nesting grounds and in the marine environment is unknown for both albatross species.

- **Reasonably Foreseeable Future External Effects.** New seabird protection measures have recently been established for the Hawaiian pelagic longline fleets and are expected to reduce take of albatross in those fisheries . Incidental take of black-footed and Laysan albatross in foreign longline fisheries is expected to remain high and continue to exceed the threshold for population level effects.

- **Cumulative Effects.** Since the populations of black-footed and Laysan albatross are undergoing measurable declines and several human-caused mortality factors have been identified and are expected to continue in the future, including contributions from the groundfish fisheries under FMP 2.1 and FMP 2.2, the cumulative effects on black-footed and Laysan albatross are considered to be significantly adverse at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a very small amount of squid and forage fish as bycatch under FMP 2.1 and FMP 2.2 and an unknown amount of forage fish in a potential directed fishery under FMP 2.1. This effect is considered insignificant at the population level for both albatross species. While groundfish vessels contribute to overall marine

pollution through accidental spills and vessel accidents, the effects of this pollution on albatross prey populations can not be assessed at this time.

- **Persistent Past Effects.** Albatross primarily prey on squid species and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to climate and oceanographic factors. Since albatross can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources have potentially affected albatross prey in the past. However, very little is known about the specific toxicological effects on species important to these seabirds or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on albatross prey availability. Pollution is likely to affect albatross prey in the future, but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey to albatross, can not be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of albatross prey is considered to be insignificant at the population level for all species.

Benthic Habitat

Since albatross feed at the surface or with shallow dives, and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on albatross prey. Therefore, no cumulative effect is identified for these species.

4.6.7.3 Shearwaters

Direct/Indirect Effects of FMP 2.1 and 2.2

Incidental Take

As described in Section 4.6.7.1, longline effort in the BSAI is expected to be about the same as under the baseline condition, and is expected to almost double in the GOA under FMP 2.1. Incidental take of shearwaters on longlines is therefore expected to be the same as the baseline condition in the BSAI. Since there is not a strong correlation between fishing effort and incidental take of any species besides fulmars, the increased longline effort in the GOA may translate into similar or slightly increased levels of shearwater take as the baseline condition. These levels of incidental take are considered insignificant at the population level for both species (see Section 4.5.7.2). FMP 2.1 is also expected to increase incidental take in trawl gear and vessel strikes due to a major increase in trawl effort. It is not known whether there is a direct proportional relationship between trawl effort and incidental take of shearwaters. However, if we assume that take levels would increase 300 percent in direct response to the increased level of trawl effort, take of shearwaters in trawls would average about 2,400 birds per year (Table 3.7-4, using the mean of low and high estimates). These levels of take are very small relative to the abundance of these species (estimated at a combined 54 million birds) and are therefore considered to be insignificant at the population level. FMP 2.1 is therefore considered to have insignificant effects on these species through overall incidental take.

Under FMP 2.2, the seabird protection measures for longline vessels would be the same as the baseline condition and longline effort is predicted to be about the same as under the baseline condition. The predicted level of incidental take of these shearwater species on longlines would therefore approximate the baseline levels described in Section 4.5.7.2, which are considered insignificant at the population level. Trawl effort is expected to increase under FMP 2.2 by approximately 25 percent over the baseline condition. If it is assumed that this increase in effort will result in a corresponding increase in incidental take, take of shearwaters in trawls would average about 1000 birds per year (Table 3.7-4, using the mean of low and high estimates). This level of take is very small relative to the abundance of these species and is therefore considered to be insignificant at the population level. The overall effect of FMP 2.2 on these species is therefore considered to be insignificant through incidental take.

Changes in Food Availability

Shearwaters forage over vast areas of ocean and are therefore unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 2.1 or FMP 2.2, even if a directed forage fish fishery develops. FMP 2.1 and FMP 2.2 are therefore considered to have insignificant effects on these species through availability of food.

Benthic Habitat

Shearwaters are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 2.1 or FMP 2.2. FMP 2.1 and FMP 2.2 are therefore considered to have no effects on these species through benthic habitat.

Cumulative Effects of FMP 2.1 and FMP 2.2

The past/present effects on these shearwater species are described in Section 3.7.6 (Table 3.7-14) and the predicted direct and indirect effects of the groundfish fishery under FMP 2.1 and FMP 2.2 are described above (Table 4.5-54). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for these species would be dominated by factors external to the groundfish fisheries and would be the same as those described in Section 4.5.7.2 (Table 4.5-54) and summarized below.

Mortality

- **Direct/Indirect Effects**. Under this alternative, the same seabird protection measures that are described in the baseline conditions (see Section 3.7.1) would be maintained. The predicted level of incidental take from all gear types is considered insignificant at the population level for both species in this group.

- **Persistent Past Effects.** For sooty and short-tailed shearwaters, mortality factors include large contributions from subsistence and commercial harvest of chicks on the nesting grounds as well as climatic and oceanic fluctuations that cause periodic mass starvation, substantial contributions from foreign, Hawaiian, and BSAI/GOA groundfish longline and trawl fisheries, and a smaller contribution from vessel collisions throughout their range. It is difficult to assess the population trends in these abundant and widespread species but there is some indications that both species may

be declining. The contribution of toxic and plastic pollution on their nesting grounds and in the marine environment is unknown.

- **Reasonably Foreseeable Future External Effects.** New seabird protection measures have recently been established for the Hawaiian pelagic longline fleets but they are not expected to reduce take of shearwaters in those fisheries. Incidental take of shearwaters in foreign fisheries will likely continue as in the past unless longline and trawl deterrence techniques are developed and applied that are effective for diving species.

- **Cumulative Effects.** Since the populations of shearwaters may be undergoing declines, and several human-caused mortality factors have been identified that are expected to continue in the future, including contributions from the groundfish fisheries under FMP 2.1 and FMP 2.2, the cumulative effects on sooty and short-tailed shearwaters are considered to be conditionally significant adverse at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a very small amount of squid as bycatch under FMP 2.1 and FMP 2.2, even with a potential directed forage fish fishery under FMP 2.1. This effect is considered insignificant at the population level for both species. While groundfish vessels contribute to overall marine pollution through accidental spills and vessel accidents, the effects of this pollution on shearwater prey populations can not be assessed at this time.

- **Persistent Past Effects.** Short-tailed and sooty shearwaters are susceptible to periodic widespread food shortages that have caused massive die-offs in Alaskan waters. Natural fluctuations in primary productivity and oceanographic factors are considered to be the driving forces that determine the abundance of their main prey (euphausiids), rather than competitive interactions with other predators. Since shearwaters can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources has potentially affected shearwater prey in the past. However, very little is known about the specific toxicological effects on species important to these seabirds or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on shearwater prey availability. Pollution is likely to affect shearwater prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey to shearwaters, can not be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of shearwater prey is considered to be insignificant at the population level for both species.

Benthic Habitat

Since shearwaters feed at the surface or with shallow dives, and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effect is identified for these species.

4.6.7.4 Northern Fulmar

Direct/Indirect Effects of FMP 2.1

Incidental Take

Mortality of northern fulmars on longline gear accounts for the majority of all birds taken incidentally in the groundfish fisheries under the baseline conditions. Under FMP 2.1, incidental take on longlines is predicted to remain similar to its present level because of similar effort and avoidance measures as the baseline condition (see Section 4.5.7.3). Incidental take in trawl gear and by vessel strikes (about 3150 fulmars per year under baseline conditions) is expected to increase by an unknown amount with the predicted 200 to 300 percent increase in trawl effort under FMP 2.1. Even if we assumed a direct relationship with trawl effort that resulted in a 300 percent increase in fulmar take, the overall numbers of fulmars taken in the groundfish fishery would still be small relative to their abundance in the BSAI/GOA (close to one percent of their estimated 2 million population). Fulmar population dynamics, and the potential effects of different levels of mortality or mortality of adults versus subadults, have not been explored with mathematical modeling. Given the fact that fulmar population trends are presently measured only on the Pribilofs and not on their largest colonies, it is unlikely that anthropogenic mortality equal to an estimated one percent of their population would have a detectable effect on the overall population. However, concern for a colony level effect would be intensified (see Section 4.5.7.3), especially since the existing fishing restrictions around the Pribilof Islands would be lifted under FMP 2.1. If trawl and longline effort increased substantially around the Pribilofs during the breeding season and a high percentage of the incidentally taken fulmars came from the Pribilof colony, incidental take of fulmars under FMP 2.1 could be significant at the colony level. Given the conjectural nature of these conditions occurring, FMP 2.1 is considered to be conditionally significant adverse for incidental take of fulmars.

Changes in Availability of Food

Fulmars forage over vast areas of ocean and are therefore unlikely to be affected by any potential localized disturbance or depletion of prey from the fishery as managed under FMP 2.1, even if a directed forage fish fishery develops. FMP 2.1 is therefore considered to have insignificant effects on fulmars through availability of food.

Benthic Habitat

Fulmars are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 2.1. FMP 2.1 is therefore considered to have no effects on fulmars through benthic habitat.

Cumulative Effects of FMP 2.1

The past/present effects on northern fulmars are described in Section 3.7.5 (Table 3.7-13) and the predicted direct and indirect effects of the groundfish fishery under FMP 2.1 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.6-4 and summarized below.

Mortality

- **Direct/Indirect Effects.** Under FMP 2.1, the same seabird protection measures for the longline fleet that are described in the baseline conditions (section 3.7.1) would be maintained. The incidental take of fulmars under FMP 2.1 is expected to be similar to the baseline level in the longline sector, and much higher in the trawl sector due to increased effort. The overall effect of the fishery on fulmar mortality is considered conditionally significant adverse because of increased concern for colony level effects.

- **Persistent Past Effects.** For northern fulmars, past mortality factors include large contributions from the BSAI/GOA groundfish fisheries and other net and longline fisheries in the North Pacific and Bering Sea. There is no indication of an area-wide population decline, but there is some concern that particular colonies may be experiencing declines related to the groundfish fisheries. Other potential mortality factors that have been identified include acute and chronic effects of pollution, underestimated mortality in all fisheries, and higher than normal rates of natural mortality (i.e. starvation) due climatic and oceanographic fluctuations.

- **Reasonably Foreseeable Future External Effects.** Incidental take of fulmars is expected to continue in all offshore fisheries in the BSAI/GOA. The IPHC fisheries will be subject to new seabird avoidance measures, so incidental take from the halibut and sablefish fleet is expected to decline substantially. Future oil spills and other incidents of pollution are likely, but their effects on fulmars will depend on many factors that can not be predicted.

- **Cumulative Effects.** Incidental take in the groundfish fishery under FMP 2.1 is expected to be the primary human-caused mortality factor for fulmars. Because fishing intensity is expected to increase substantially around the Pribilof Islands, the cumulative effect on fulmar mortality is considered conditionally significant adverse because of increased concern for colony level effects.

Changes in Food Availability

- **Direct/Indirect Effects.** The groundfish fisheries would continue to take a small amount of forage fish and pelagic invertebrates as bycatch under FMP 2.1, and an unknown amount of these prey if a directed forage fish fishery developed. This effect is considered insignificant at the population level for northern fulmars. While groundfish vessels contribute to overall marine pollution through accidental spills and vessel accidents, the effects of this pollution on fulmar prey populations can not be assessed at this time.

- **Persistent Past Effects.** Fulmars prey on squid and small schooling fishes that have been targeted by fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be minimal compared to climate and oceanographic factors. Since fulmars can forage over huge areas, they are unlikely to have been affected by localized disturbance or depletion of their prey fields caused by fisheries. Pollution from a variety of land and marine sources have potentially affected fulmar prey in the past. However, very little is known about the specific toxicological effects on species important to fulmars or what sources of pollution may be the most important.

- **Reasonably Foreseeable Future External Effects.** There are no foreseeable fisheries that will likely have more than a negligible effect on fulmar prey availability. Pollution is likely to affect fulmar prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey to fulmars, can not be made at this time.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance and distribution of fulmar prey is considered to be insignificant at the population level.

Benthic Habitat

Since fulmars feed at the surface or with shallow dives, and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernible effect on their prey. Therefore, no cumulative effect is identified for this species.

Direct/Indirect Effects of FMP 2.2

Incidental Take

For the reasons described above, the incidental take of fulmars on longlines under FMP 2.2 would be expected to be approximately the same as described under the baseline conditions (Section 4.5.7.3). This level is considered insignificant at the population level for fulmars. Trawl effort is expected to increase under FMP 2.2 by approximately 25 percent over the baseline condition. If we assume that this increase in effort will result in a corresponding increase in incidental take, take of fulmars in trawls and vessel strikes would average about 4,000 birds per year. The combined take from longlines and trawls would be approximately 16,000 birds per year (see Section 4.5.7.3) which is less than one percent of the estimated BSAI/GOA population of 2 million birds.

This level of take would be considered insignificant at the population level. However, there would still be concern about potential colony level effects and the USGS/BRD would likely continue to investigate the issue. The existing trawl restrictions around the Pribilof Islands would be maintained under FMP 2.2 so the increase in trawl effort would not be concentrated near the fulmar colony. While these investigations continue, it will be assumed for this analysis that FMP 2.2 would not lead to a disproportionate take of fulmars from any one colony. The overall effect of FMP 2.2 on fulmars is therefore considered to be insignificant through incidental take.

Changes in Availability of Food

FMP 2.2 would have the same insignificant effects on fulmar food availability as described above for FMP 2.1

Benthic Habitat

FMP 2.2 would have no effects on fulmar benthic habitat as described above for FMP 2.1.

Cumulative Effects – FMP 2.2

Mortality

- **Direct/Indirect Effects.** The seabird protection measures under FMP 2.2 would be the same as described above for FMP 2.1. However, the structure and intensity of the fisheries would be substantially different than FMP 2.1. Although concern for colony level effects remain, the effect of the fishery under FMP 2.2 is considered insignificant at the population level.

- **Persistent Past Effects and Reasonably Foreseeable Future External Effects.** These effects would be the same as described above for FMP 2.1.

- **Cumulative Effects.** Incidental take in the groundfish fishery under FMP 2.2 is expected to be the primary human-caused mortality factor for fulmars. Incidental take in the IPHC fisheries is expected to decrease, and at least partially compensate for, the small increase in take expected in the groundfish fishery. The cumulative effect on fulmar mortality is therefore considered insignificant at the population level.

Changes in Food Availability and Benthic Habitat

These effects would be the same as described above for FMP 2.1.

4.6.7.5 Species of Management Concern (Red-Legged Kittiwakes, Marbled and Kittlitz's Murrelets)

Direct/Indirect Effects of FMP 2.1

Incidental Take

The seabird avoidance measures under FMP 2.1 would be the same as under the baseline conditions and would be limited to the longline fleet. Under the baseline conditions, no red-legged kittiwakes have been observed to be taken in any of the BSAI/GOA fisheries since data began to be collected in 1993. Under FMP 2.1, longline effort would remain about the same as the baseline in the BSAI, while trawling would increase substantially. The Pribilof Habitat Conservation Area, which covers a large area around the largest red-legged kittiwake colony on St. George Island, would be eliminated along with many other fishery closures. The elimination of this closed area would result in an increased potential for incidental take of red-legged kittiwakes around the Pribilof Islands. However, since incidental take approaches zero under the current conditions, it appears that the species is not very susceptible to being taken in any gear, perhaps because they can not compete for offal with the larger gulls or are more agile in avoiding entanglement. It seems most likely that these birds will continue to be able to successfully avoid being taken on a regular basis, even with increased fishing effort. The effect of FMP 2.1 on incidental take of red-legged kittiwakes is therefore considered insignificant at the population level.

Murrelets, due to their small size and feeding strategy, are more susceptible to being taken in trawls than in either longline or pot fisheries. The 200 to 300 percent increase in trawling under FMP 2.1 would result in an increased potential for incidental take of these species. However, since murrelets prefer to forage in waters inshore of the groundfish fisheries, and the incidental take of murrelets under the baseline conditions already

approaches zero, the potential increase in take would likely be very small. The effect of FMP 2.1 on incidental take of marbled and Kittlitz's murrelets is therefore considered insignificant at the population level.

Changes in Food Availability

Given the wide variety of foods used by kittiwakes and the extensive areas over which they forage, it seems unlikely, even with the substantial increased trawling activity, that they would be susceptible to localized depletion of prey during the non-breeding season. However, while nesting, kittiwakes are more dependent on high-quality forage fish for raising chicks and are more susceptible to potential localized depletions of prey around their colonies. Elimination of the Pribilof Habitat Conservation Area fishery closure would likely result in increased trawling around the largest red-legged kittiwake colony, St. George Island. More importantly than trawl bycatch, the existing ban on the development of a directed forage fish fishery would be lifted under FMP 2.1. It is not clear how such a fishery would be structured or how extensive it would become (see Section 4.6.4), but if such a fishery developed around the Pribilofs it could have serious repercussions on the availability of prey to red-legged kittiwakes and could have population level effects. Because of the conjectural nature of this situation developing, the potential effect of the fishery through prey availability is rated conditionally significant adverse.

The groundfish fisheries have very little spatial overlap with murrelet foraging areas, but they do depend on forage fish schools that likely spend part of their time in waters of the EEZ. If a directed forage fish fishery developed near murrelet habitats in southeast Alaska and the GOA, forage fish populations may be affected on a regional level and could potentially affect murrelet reproductive success. As described above for kittiwakes, the potential effect of the fishery through prey availability is rated conditionally significant adverse for marbled and Kittlitz's murrelets.

Benthic Habitat

Red-legged kittiwakes are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 2.1. Marbled and Kittlitz's murrelets feed on species that depend on benthic habitats for at least part of their life cycles. However, benthic habitats in their nearshore foraging areas would not be affected directly by groundfish trawls under FMP 2.1, as these take place further offshore. FMP 2.1 is therefore considered to have insignificant effects on murrelets through benthic habitat, and no effects on red-legged kittiwakes.

Cumulative Effects of FMP 2.1

The past/present effects on red-legged kittiwakes, marbled murrelets, and Kittlitz's murrelets are described in Sections 3.7.13 and 3.7.17 (Tables 3.7-22 and 3.7-26) and the predicted direct and indirect effects of the groundfish fishery under FMP 2.1 are described above (Table 4.6-4). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The cumulative effects for these species would be dominated by factors external to the groundfish fisheries and would be the same as those described in Section 4.5.7.2 (Table 4.6-4) and summarized below.

Mortality

- **Direct/Indirect Effects.** The incidental take of red-legged kittiwakes and both murrelets species is expected to be rare and therefore insignificant at the population level under FMP 2.1.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include subsistence hunting and egging (red-legged kittiwakes), incidental take in coastal salmon gillnet and other net fisheries (murrelets), oil spills (murrelets), and logging of nest trees (marbled murrelets). Incidental take in the BSAI/GOA groundfish fisheries appears to have contributed very little to the mortality of these species.

- **Reasonably Foreseeable Future External Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future. For red-legged kittiwakes, the introduction of nest predators or a large oil spill around the Pribilof Islands in nesting season could have significant effects on mortality. For the murrelet species, oil spills in nearshore habitats and incidental take in salmon and other net fisheries are likely to remain the largest factors in the future. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may also contribute to future mortality. If the Kittlitz's murrelet population continues to decline and the species is listed under the ESA, new regulations may be placed on the various nearshore net fisheries to monitor and reduce incidental take of the species. These measures would also benefit marbled murrelets.

- **Cumulative Effects.** The three species in this group have all experienced substantial population declines in the recent past, and are all susceptible to future human-caused mortality factors, including potentially small contributions from the groundfish fishery. The decline of red-legged kittiwakes on the Pribilofs may have been reversed recently, but it is not clear if their recovery will continue in the future. The cumulative effect for red-legged kittiwakes is therefore considered conditionally significant adverse at the population level through mortality. Both murrelet species continue to decline in their core areas, and are thus considered to have significantly adverse cumulative effects at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects.** A directed forage fish fishery could develop under this FMP that could lead to population level effects on all three species. The effect of FMP 2.1 is therefore considered conditionally significant adverse at the population level for all three species in this group. While groundfish vessels contribute to overall marine pollution and disturbance, the effects of vessel hazzards on seabird prey populations can not be assessed at this time.

- **Persistent Past Effects.** All three species prey on small schooling fishes and an assortment of invertebrates that have been targeted or taken as bycatch by external fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be small compared to climate and oceanographic factors. Pollution from a variety of land and marine sources, including the EVOS, have likely affected the prey of these species in the past. Since murrelets are easily disturbed by marine vessels of all kinds, high concentrations of vessel traffic in some areas may have effectively excluded murrelets from certain important foraging areas.

- **Reasonably Foreseeable Future External Effects.** Future squid and herring fisheries as well as other net fisheries that take forage fish as bycatch may have an effect on prey availability for these species. Pollution is also likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey on a scale important to the birds, can not be made at this time.

- **Cumulative Effects.** The dynamic interaction of natural and human-caused events, including fisheries and pollution, on the availability of forage fish and invertebrate prey to seabirds is only beginning to be explored with directed research. However, the potential of the groundfish fisheries under FMP 2.1 to have a significantly adverse effect on prey availability leads to a cumulative effects rating of conditionally significant adverse for these three species.

Benthic Habitat

Red-legged kittiwakes are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of the groundfish fishery. Therefore, no cumulative effect is identified for red-legged kittiwakes. Marbled and Kittlitz's murrelets feed on species that depend on benthic habitats for at least part of their life cycles, but they forage in shallow waters that are inshore of the groundfish fishery. Since the groundfish fishery would have minor contributions to potential effects on benthic habitats important to murrelets, the cumulative effects for these species are considered insignificant.

Direct/Indirect Effects of FMP 2.2

Incidental Take

Under FMP 2.2, longline fishing effort would be similar to the baseline in both the BSAI and GOA. Incidental take of red-legged kittiwake would therefore be similar to the baseline, which approaches zero. Trawl effort would increase by a modest amount under FMP 2.2 but, as described above for FMP 2.1, would not be expected to substantially increase incidental take of murrelets or kittiwakes. The effect of FMP 2.2 on incidental take of these species is therefore considered insignificant at the population level.

Availability of Food

As described in Section 4.5.7.4, the potential effects of the groundfish fishery on kittiwake and murrelet prey availability are considered to be insignificant under the baseline conditions. Although trawl effort is predicted to increase by 25 percent under FMP 2.2, it is unlikely that the attendant increase in bycatch of forage fish would affect prey availability enough to cause population level effects on these species (see Sections 4.6.4 and 4.6.10). The existing ban on the development of a directed forage fish fishery would remain in effect under FMP 2.2. The overall effect of FMP 2.2 on the availability of food for species of management concern is therefore considered insignificant at the population level.

Benthic Habitat

There are no effects on these species through benthic habitat under FMP 2.2, as described above for FMP 2.1.

Cumulative Effects of FMP 2.2

The seabird protection measures under FMP 2.2 would be the same as described above for FMP 2.1. The cumulative effects for mortality of these species are dominated by factors external to the fishery and would lead to the same conclusions as described above for FMP 2.1. Without the potential for a directed forage fish fishery, the potential effects of FMP 2.2 on prey availability are unknown, and lead to a cumulative effects rating of unknown. The groundfish fishery only makes a minor contribution to effects on benthic habitat, so insignificant cumulative effects are identified for murrelet species. No cumulative effect is identified for red-legged kittiwakes because they are not benthic feeders (Table 4.5-56).

4.6.7.6 Other Piscivorous Species (Most Alcids, Gulls, and Cormorants)

Direct/Indirect Effects of FMP 2.1

Incidental Take

The incidental take of piscivorous seabirds on longlines under FMP 2.1 would be expected to be similar to the baseline levels which are considered insignificant at the population level for these species (see Section 4.5.7.5). Incidental take in trawls would be expected to increase from baseline conditions due to increased trawl effort, but would not be expected to have population level effects for any species in this group because of the very low levels of take relative to the populations of these abundant species. For these reasons, FMP 2.1 is considered to have insignificant effects on piscivorous species through incidental take.

Changes in Food Availability

As described in Section 4.5.7.5, the potential effect of the groundfish fishery on piscivore prey availability is considered to be insignificant under the baseline conditions. The availability of food in the form of fishery discards would be expected to increase substantially with the overall increase in TAC under FMP 2.1. Some species of large gulls may benefit on the population level from this increase in supplemental food supplies while other species, like kittiwakes and murres, experience an adverse effect from increased predation pressure from the large gulls. The net beneficial or adverse effects of fishery wastes to the different species in this group are unknown.

Although trawl effort is predicted to increase substantially under FMP 2.1, bycatch of forage fish and pelagic invertebrates in groundfish trawls is not expected to affect the abundance and distribution of forage fish enough to cause population level effects on piscivores (see Sections 4.6.4 and 4.6.10). However, the existing ban on the development of a directed forage fish fishery would be lifted under FMP 2.1. It is not clear how such a fishery would be structured or how extensive it would become. Under certain conditions, such a fishery could result in localized depletions of forage fish important to seabirds that could have population level effects, especially if they occurred near breeding colonies during chick-rearing season. Because of the conjectural nature of this situation developing, the potential effect of the fishery through prey availability is rated conditionally significant adverse.

Benthic Habitat

Cormorants and alcids sometimes feed in the demersal zone, and some of their prey depend on benthic habitats during various life cycle stages. Bottom trawling and pelagic trawling that makes contact with the

ocean bottom have the greatest potential to indirectly affect these diving seabirds via physical changes to the complexity and productivity of benthic habitats that may affect their prey base (NRC 2002). Although area-specific effects of trawling on seabird prey species (through habitat change rather than by direct take) are poorly known, overall trawl effort in the BSAI/GOA under FMP 2.1 is predicted to increase 200 to 300 percent relative to the baseline condition and, since the effects of repeated trawling are cumulative, benthic habitat important to diving seabirds could be affected substantially over time. The overall effects of increased trawling under FMP 2.1 are therefore considered conditionally significant adverse on piscivorous seabirds.

Cumulative Effects of FMP 2.1

The past/present effects on the species in this group, including most alcids, gulls, and cormorants, are described in the species accounts of Section 3.7 (Tables 3.7-16 and 3.7-20) and the predicted direct and indirect effects of the groundfish fishery under FMP 2.1 are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.6-4 and summarized below.

Mortality

- **Direct/Indirect Effects.** Although incidental take of alcids is expected to increase under FMP 2.1 due to increased trawl effort, the incidental take of all species in this group is expected to be insignificant at the population level.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include subsistence hunting and egging, incidental take in a variety of foreign and U.S. coastal and pelagic fisheries, oil spills and other pollution (including huge losses at some colonies from the EVOS, fox farming, and regime shifts that have caused episodes of mass starvation. Incidental take in the BSAI/GOA groundfish fisheries appears to have contributed relatively little to the mortality of these species.

- **Reasonably Foreseeable Future External Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future except for fox farming. A similar, though unintentional, effect is the possible introduction of nest predators (i.e. rats) to seabird colonies. Conservation concerns focus on preventing potential impacts around breeding colonies during the nesting season since populations are concentrated in time and space. For some species, human impacts in nearshore habitats will likely have a much greater effect on their populations than offshore fisheries. The contribution from chronic sources of pollution, from both terrestrial and marine sources, may also contribute to future mortality.

- **Cumulative Effects.** Although a number of past and future human-caused mortality factors, including potentially small contributions from the groundfish fishery, have been identified for the species in this group, none of them have experienced substantial, consistent, or area-wide population declines in the recent past. The cumulative effects for these species are therefore considered insignificant at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects.** Because of the potential development of directed forage fish fisheries, the effect of FMP 2.1 on the abundance and distribution of seabird prey species is considered conditionally significant adverse at the population level for all species in this group. While groundfish vessels contribute to overall marine pollution and disturbance, the effects of vessel hazzards on seabird prey populations can not be assessed at this time.

- **Persistent Past Effects.** All species in this group prey on small schooling fishes and an assortment of invertebrates that have been targeted or taken as bycatch by external fisheries in various parts of their range. While these fisheries may have caused some localized depletions of prey, their effect on overall prey abundance is considered to be small compared to climate and oceanographic factors. Pollution from a variety of land and marine sources have likely affected the prey of these species in the past. Since some of the alcids are easily disturbed by marine vessels of all kinds, high concentrations of vessel traffic in some areas may have effectively excluded them from certain important foraging areas.

- **Reasonably Foreseeable Future External Effects.** Future squid and herring fisheries, as well as other net fisheries that take forage fish as bycatch, may have an effect on prey availability for these species. Pollution is also likely to affect prey in the future but specific predictions on the nature and scope of the effects, especially as it relates to the availability of prey on a scale important to the birds, can not be made at this time.

- **Cumulative Effects.** Since the groundfish fisheries under FMP 2.1 may include a directed fishery on forage fish, the effects of which are potentially adverse under certain conditions, the cumulative effects on prey availability are considered to be conditionally significant adverse for these species.

Benthic Habitat

- **Direct/Indirect Effects.** Trawl effort would increase substantially under FMP 2.1, and would have the potential to modify benthic habitats and have indirect effects on the food web of diving piscivorous species. The overall effects of FMP 2.1 on piscivorous seabirds through potential changes in benthic habitat are considered conditionally significant adverse.

- **Persistent Past Effects.** Benthic habitats important to the diving species in this group have been affected by various foreign and U.S. fisheries for many years, and include nearshore as well as offshore fisheries. The magnitude and longevity of the effects of these different types of fisheries have only begun to be investigated so it is unclear what or where habitat effects are persistent, especially in regard to the indirect effects on prey species important to seabirds. Natural sources of benthic habitat disruption, such as strong ocean currents, ice scouring, and foraging by gray whales and walrus, may also have persistent effects in certain areas.

- **Reasonably Foreseeable Future External Effects.** All future fisheries in the BSAI/GOA that use bottom contact fishing gear are likely to affect benthic habitat to some extent. Natural sources of benthic habitat disruption will also continue.

- **Cumulative Effects.** Since the groundfish fisheries under FMP 2.1 will contribute in a potentially significant way to the many human-caused and natural factors that may alter benthic habitats, the cumulative effects of these changes as they relate to the food web important to piscivorous seabirds are considered conditionally significant adverse.

Direct/Indirect Effects of FMP 2.2

Incidental Take

The incidental take of piscivorous seabirds under FMP 2.2 would be expected to remain approximately the same as the baseline levels which are considered insignificant at the population level for these species (see Section 4.5.7.5).

Changes in Food Availability

As described in Section 4.5.7.5, the potential effects of the groundfish fishery on piscivore prey availability are considered to be insignificant under the baseline conditions. The availability of food in the form of fishery discards would be expected to increase in proportion to the overall increase in TAC under FMP 2.2. Some species of large gulls may benefit on the population level from this increase in supplemental food supplies while other species, like kittiwakes and murres, experience an adverse effect from increased predation pressure from the large gulls. The net beneficial or adverse effects of fishery wastes to the different species in this group are unknown.

Although trawl effort is predicted to increase by 25 percent under FMP 2.2, the attendant increase in bycatch of forage fish and pelagic invertebrates is not expected to affect prey availability enough to cause population level effects on piscivores (see Sections 4.6.4 and 4.6.10). The existing ban on the development of a directed forage fish fishery would remain in effect under FMP 2.2. The overall effect of FMP 2.2 on the availability of food for piscivorous species is therefore considered insignificant on the population level.

Benthic Habitat

Trawl effort in the BSAI/GOA is predicted to increase by 25 percent under FMP 2.2 relative to the baseline condition. This level of increase is not expected to produce a substantial change in the nature or intensity of trawl impacts relative to the baseline. The effect of FMP 2.2 on benthic habitat important to piscivorous seabirds is therefore considered insignificant.

Cumulative Effects of FMP 2.2

The only factors of the cumulative effects analysis for FMP 2.2 that would vary from those described above for FMP 2.1 are the contributions of the groundfish fishery. The contributions of the fishery to direct mortality, prey availability, and benthic habitat are all considered insignificant at the population level under FMP 2.2. Since the combination of past events have not resulted in population level effects, and no foreseeable future events are likely to change the situation, the cumulative effects of mortality, prey availability, and benthic habitat under FMP 2.2 are considered insignificant (Table 4.5-57).

4.6.7.7 Other Planktivorous Species (Storm-Petrels and Most Auklets)

Direct/Indirect Effects of FMP 2.1 and 2.2

Incidental Take

As described in Section 4.5.7.6, the incidental take of planktivorous species is very small under the baseline conditions relative to their abundance in the BSAI/GOA. Under FMP 2.1 and FMP 2.2, trawl effort would increase while longline effort is predicted to remain similar to the baseline level. Since very few storm-petrels or auklets are taken in either the longline or trawl fisheries, the predicted changes in fishing effort would be unlikely to result in substantial changes in take from the baseline conditions. The increased trawl effort could lead to an increase in bird mortality from vessel strikes, but it is unlikely that this would have population level effects given the infrequent nature of the events and relatively small numbers of birds involved (Section 4.5.7.6). The overall effect of FMP 2.1 or FMP 2.2 on the incidental take of planktivorous species is therefore considered insignificant at the population level.

Changes in Food Availability

The groundfish fisheries would continue to take a small amount of forage fish and invertebrate prey as bycatch under FMP 2.1 and FMP 2.2. FMP 2.1 would also remove the ban on development of directed forage fish fisheries. Although it is not known whether such a fishery would actually develop or what its structure and intensity would be, it would likely take a higher rate of seabird prey as bycatch than other target fisheries. However, it is unlikely that a forage fish fishery would have more than a negligible effect on the availability of prey to planktivorous seabirds.

One potential connection between the groundfish fishery and the abundance of planktonic prey for these seabird species is described in Section 4.5.7.6. The groundfish fisheries could indirectly affect the availability of zooplankton and small schooling fish to seabirds through changes in the abundance and distribution of target fish species that also prey on small fish and zooplankton. For example, since young pollock are planktivores, it could be argued that changes in fishery management that led to decreased abundance of pollock populations (e.g., greater fishing effort) would decrease competition for prey and hence improve the carrying capacity for storm-petrels and auklets. However, zooplankton and juvenile fish abundance and distribution are thought to be influenced much more by primary productivity and oceanographic fluctuations than predator/prey relationships (see 3.7.1). The effects of the fisheries on prey availability for planktivorous seabird species, as managed under FMP 2.1 or FMP 2.2, are therefore expected to be insignificant on the population level for these seabird species.

Benthic Habitat

Storm-petrels and auklets are not benthic feeders and are not expected to be affected by any changes in benthic habitat that might occur as a result of fishery management under FMP 2.1 or FMP 2.2. Therefore, both FMPs are considered to have no effects on these species through benthic habitat.

Cumulative Effects of FMP 2.1 and FMP 2.2

The past/present effects on the species in this group are described in Sections 3.7.7 and 3.7.18 (Tables 3.7-15 and 3.7-27) and the predicted direct and indirect effects of the groundfish fishery are described above. This

section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-58 and summarized below.

Mortality

- **Direct/Indirect Effects.** Although incidental take of alcids is expected to increase due to increased trawl effort, the incidental take of all species in this group is expected to be insignificant at the population level.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include subsistence harvest, incidental take in foreign and U.S. coastal and pelagic fisheries, oil spills and other marine pollution, fox farming, and regime shifts that have caused episodes of mass starvation. Incidental take in the BSAI/GOA groundfish fisheries appears to have contributed relatively little to the mortality of these species.

- **Reasonably Foreseeable Future External Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future except for fox farming. A similar, though unintentional, effect is the possible introduction of nest predators (i.e. rats) to seabird colonies. The contribution from chronic sources of pollution, both from terrestrial and marine sources, may also contribute to future mortality.

- **Cumulative Effects.** Although a number of past and future human-caused mortality factors, including potentially small contributions from the groundfish fishery, have been identified for the species in this group, none of them have experienced substantial, consistent, or area-wide population declines in the recent past. The cumulative effects for these species are therefore considered insignificant at the population level through mortality.

Changes in Food Availability

- **Direct/Indirect Effects.** FMP 2.1 would remove the ban on development of directed forage fish fisheries. Although it is not known whether such a fishery would actually develop or what its structure and intensity would be, it would likely take a higher rate of seabird prey as bycatch than other target fisheries. However, it is considered unlikely that a forage fish fishery would have more than a negligible effect on the availability of prey to planktivorous seabirds. Indirect effects on zooplankton and juvenile fish abundance through changes in the abundance of target fish predators is considered minor compared to seasonal changes in primary productivity and oceanographic factors. The effect of the fishery on the abundance and distribution of seabird prey species is considered insignificant at the population level for all species in this group.

- **Persistent Past Effects.** Factors that have affected the abundance and distribution of zooplankton and juvenile fish include bycatch in squid and forage fish fisheries, marine pollution, and the decimation of planktivorous whales by commercial whaling. These effects are considered minor compared to seasonal and oceanographic fluctuations.

- **Reasonably Foreseeable Future External Effects.** Future squid and herring fisheries as well as other net fisheries that take forage fish as bycatch may have minimal effects on prey availability for these species. Pollution is also likely to affect prey in the future, but specific predictions on the

nature and scope of the effects, especially as it relates to the availability of prey on a scale important to the birds, can not be made at this time.

- **Cumulative Effects.** The groundfish fisheries contribute in an indirect way to human influences on planktonic prey availability, which are considered minimal compared to natural fluctuations. These cumulative effects are considered insignificant on the population level for all species in this group.

Benthic Habitat

Since these planktivorous seabirds feed at the surface or with shallow dives, and their prey live in the upper and middle levels of the water column, potential changes in benthic habitat from groundfish trawls or any other fishing gear would have no discernable effect on their prey. Therefore, no cumulative effects are identified for these species.

4.6.7.8 Spectacled Eiders and Steller's Eiders

Direct/Indirect Effects of FMP 2.1 and 2.2

Incidental Take

Spectacled eiders interact very little, if at all, with the groundfish fisheries under the baseline conditions (see Section 4.5.7.7). There are no changes in the fishery under FMP 2.1 or FMP 2.2 that would be expected to affect this situation. The groundfish fisheries are therefore expected to have incidental take of spectacled eiders approaching zero under FMP 2.1 and FMP 2.2.

Steller's eider have very little overlap between their foraging areas and the groundfish fisheries, and have thus been taken very rarely under the baseline conditions (see Section 4.5.7.7). In the one area that overlaps with the groundfish fishery, Kuskokwim Shoals, the fishery has not been restricted in the past but has been limited by its distance from ports of delivery and lack of interest by the fleet. An increase in the overall TAC is therefore not likely to lead to a proportional increase in effort in Kuskokwim Shoals. Incidental take of Steller's eider is therefore expected to continue to be very rare under FMP 2.1 and FMP 2.2, and is considered to have insignificant effects on their population levels.

Changes in Food Availability

The groundfish fisheries are not expected to overlap in space or time with spectacled eider critical habitat under FMP 2.1 or FMP 2.2. Therefore, no effects on spectacled eider food availability have been identified. Since there would be very little overlap between groundfish fisheries and critical habitat for Steller's eiders under FMP 2.1 or 2.2, the effects of the groundfish fisheries on prey abundance and availability are considered insignificant at the population level.

Benthic Habitat

As discussed in Section 4.5.7.7, there has been no overlap between the groundfish trawl fisheries and spectacled eider habitat. Neither FMP 2.1 nor FMP 2.2 are expected to change this situation, and are therefore considered to have no effects on spectacled eiders through benthic habitat changes.

For Steller's eiders, potential trawl effort in their critical habitat is limited to Kuskokwim Bay. Since the fishery in this area is not restricted under the baseline conditions and has been apparently limited only by lack of interest from the fleet, no changes in management under FMP 2.1 or FMP 2.2 would promote an increase use of this area. Potential effects are therefore likely to remain similar to the baseline condition and are considered insignificant.

Cumulative Effects of FMP 2.1 and FMP 2.2

The past/present effects on spectacled and Steller's eiders are described in Sections 3.7.9 and 3.7.10 (Tables 3.7-17 and 3.7-18) and the predicted direct and indirect effects of the groundfish fishery are described above. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in a cumulative way. The effects considered in this analysis are listed in Table 4.5-59 and summarized below.

Mortality

- **Direct/Indirect Effects.** Although incidental take of diving seabirds is expected to increase under FMP 2.1 and FMP 2.2 due to a major increase in trawl effort, this additional fishing is not expected to take place in areas important to eiders. Incidental take of spectacled eider is predicted to remain at or near zero. Incidental take of Steller's eider is expected to be very rare under FMP 2.1 and FMP 2.2, and is therefore considered to be insignificant at the population level.

- **Persistent Past Effects.** Past sources of mortality that may continue to have an effect on these species include sport hunting and subsistence harvest in Russia and Alaska, incidental take in Russian and Alaskan coastal fisheries, oil spills and other marine pollution that causes physiological stress and reduces survival rates, lead shot poisoning on the nesting grounds, and collisions with vessels and other structures. Incidental take in the BSAI/GOA groundfish fisheries appears to have been very rare for Steller's eider. Both species have been afforded protection through the ESA.

- **Reasonably Foreseeable Future External Effects.** All of the mortality factors listed above in persistent past effects are likely to continue in the future. Conservation concerns focus on preventing potential impacts in critical habitat areas.

- **Cumulative Effects.** The groundfish fisheries do not contribute to direct mortality of spectacled eiders, so no cumulative effect is identified for that species. Decreased adult survival rates appear to have driven the past population decline of Steller's eiders. Known sources of direct human-caused mortality of Steller's eider, including very rare incidental take in the groundfish fisheries, do not appear to account for the past population decline in Alaska. However, several indirect factors may be contributing to decreased adult survival rates, including climate-induced changes in habitat, concentration of predators around nesting areas due to nearby human habitation, and pollution of nearshore waters from chronic and periodic sources of petroleum products (USFWS 2003a). Since the Alaska breeding population of Steller's eiders has declined dramatically in the past and has not recovered, and because several human-induced sources of mortality have been identified as potential contributing factors to this decline, including the potential for contributions to pollution and vessel collisions from the groundfish fisheries as managed under FMP 2.1 and FMP 2.2, the cumulative effects of mortality on Steller's eiders are considered significant adverse at the population level.

Changes in Food Availability

The abundance of marine invertebrate species important to Steller's eiders, including bivalves, snails, crustaceans, and polychaete worms, could potentially be affected by disturbance to their benthic habitat. These effects will be discussed below. Although other factors external to the fisheries may influence the abundance and distribution of eider prey, the groundfish fisheries only contribute minimally to these potential effects. Therefore, an insignificant cumulative effect on prey availability is identified for Steller's eiders. There is no overlap predicted between the groundfish fisheries and spectacled eider critical habitat, therefore, no cumulative effect has been identified for spectacled eider food availability.

Benthic Habitat

- **Direct/Indirect Effects.** Bottom trawls, and to a lesser extent pelagic trawls and pot gear, disrupt benthic habitats that support the prey of eiders. Under FMP 2.1 and FMP 2.2, the groundfish fishery is not expected to occur in spectacled eider critical habitat or any other area that they typically use. A limited amount of bottom trawling is expected to overlap with Steller's eider critical habitat. The overall effects of FMP 2.1 and FMP 2.2 on Steller's eiders through potential changes in benthic habitat are considered insignificant at the population level.

- **Persistent Past Effects.** Benthic habitats important to spectacled and Steller's eiders have been affected by various trawl and pot fisheries for many years, and include nearshore as well as offshore fisheries. The magnitude and longevity of the effects of these different types of fisheries have only begun to be investigated so it is unclear what or where habitat effects are persistent, especially in regard to the indirect effects on prey species important to eiders. Natural sources of benthic habitat disruption, such as strong ocean currents, ice scouring, and foraging by gray whales and walrus, may also have persistent effects in certain areas. Climate change and ocean temperature fluctuations may also play a role in altering the benthic environment.

- **Reasonably Foreseeable Future External Effects.** All future fisheries that use bottom contact fishing gear in areas used by eiders are likely to affect benthic habitat to some extent. Natural sources of benthic habitat disruption will also continue.

- **Cumulative Effects.** There is no overlap predicted between spectacled eider critical habitat and the groundfish fisheries under FMP 2.1 and FMP 2.2, therefore no cumulative effect on benthic habitat has been identified for this species. While the groundfish fisheries are predicted to have little spatial overlap with Steller's eider habitat under FMP 2.1 or FMP 2.2, the interaction of human-caused and natural disturbances of benthic habitat important to Steller's eiders has not been examined with respect to their population declines in the past. The cumulative effects of benthic habitat disruptions over the years as they relate to the food web important to eiders are therefore considered to be unknown.

4.6.8 Marine Mammals Alternative 2 Analysis

4.6.8.1 Western Distinct Population Segment of Steller Sea Lions

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

The analysis used to determine changes in the level of incidental takes described in Section 4.5.8 was applied to establish the significance of incidental take and entanglement of marine mammals expected to occur under FMP 2.1. With regard to incidental take, FMP 2.1 is not likely to result in significant changes to the population trajectory of the western distinct population segment (western population) of Steller sea lions. An average of 8.4 Steller sea lions from the western population was estimated to have been taken incidental to groundfish fisheries from 1995 to 1999 (Angliss *et al.* 2001) (Table 4.5-60). The ratio of observed takes of Steller sea lions to observed groundfish catch (from 1995 to 1999) was multiplied by the new projected groundfish catch (all fisheries combined) to estimate incidental takes expected to occur over the next six years under this FMP. The estimated annual incidental take of Steller sea lions under FMP 2.1 in all areas combined is expected to be less than 14 based on expected catch under FMP 2.1, or about one sea lion per 220,000 mt of groundfish harvested.

The MMPA requires NOAA Fisheries (NMFS Office of Protected Resources) to assess whether human-caused mortality threatens the stability or recovery of any species of marine mammal. The MMPA defines a measurement tool for this purpose, the PBR, that is a calculated value of the maximum number of animals, not including natural mortalities, that may be removed from a stock while allowing that stock to reach or maintain its optimum sustainable population. This calculation takes into consideration the most recent population estimates, historic population trends, status of the stock in relation to historic levels (i.e., whether it is depressed or not), and potential rates of recovery. According to the most recent stock assessment, PBR for the western population of Steller sea lions is 208 animals per year (Angliss and Lodge 2002). Mortality from incidental take and entanglement in marine debris is likely to continue under FMP 2.1 at levels that are small (less than 10%) relative to PBR and is therefore considered insignificant according to the criteria set for significance (Table 4.1-6).

Fisheries Harvest of Prey Species

Changes in the fishing mortality rate for Steller sea lion prey species were calculated using output from the targeted species model which projected catch rates for the various FMPs. The estimated fishing mortality rates expected to occur under each FMP were compared to the baseline fishing mortality rate in order to apply the significance criteria established in Table 4.1-6 for determining the effects on marine mammal populations. The baseline fishing mortality rates for the individual BSAI and GOA groundfish fisheries, the fishing mortality rates projected to occur under each FMP, and the relative difference between the baseline and alternative fishing mortality rates are shown in Table 4.5-61.

Under FMP 2.1, the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 140 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals the change in the harvest of this key Steller sea lion prey species is rated significantly adverse. It is worth noting that the harvest rate of pollock in the EBS was particularly low in 2002. Due to the high abundance of EBS pollock in recent years, model predictions project a decreased pollock catch

corresponding with an increasing F in subsequent years under FMP 2.1. The harvest of EBS pollock under FMP 2.1 meets the criteria of a significantly adverse impact to Steller sea lions.

The fishing mortality rate of GOA pollock is expected to increase by an average of 100 percent relative to the comparative baseline over the next five years under FMP 2.1. This change in F is significant at the population level for Steller sea lions. Fishing mortality rates are not calculated for Aleutian Islands pollock as there was no directed Aleutian Islands pollock fishery under the baseline conditions. FMP 2.1 allows for the recommencement of an Aleutian Islands pollock fishery and would result in changes to the fishing mortality rate that would be rated as significantly adverse under the criteria established in Table 4.1-6.

Under FMP 2.1, the BSAI Pacific cod fishing mortality rate is expected to increase by 79 percent. This change is determined to be significantly adverse to Steller sea lions according to the criteria established in Table 4.1-6. Under FMP 2.1, the GOA Pacific cod fishing mortality rate is expected to increase by 64 percent. This change is determined to be significantly adverse to Steller sea lions. Changes in Aleutian Islands Atka mackerel harvest are expected to be significantly adverse to Steller sea lions with a 124 percent increase in F under FMP 2.1 relative to the baseline.

Little difference is expected relative to the baseline and among FMPs for harvest of other, non-target species that are prey for Steller sea lions (e.g. cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMPs were determined to be insignificant to Steller sea lions. The combined harvest of Steller sea lion prey species under FMP 2.1 is expected to result in population level effects that are, therefore, significantly adverse to Steller sea lions.

Spatial/Temporal Concentration of the Fishery

The spatial/temporal measures for Steller sea lions in FMP 1 (and retained throughout all of the FMPs) were designed with the objective of reducing competitive interactions between groundfish fisheries and Steller sea lions in their key foraging areas during periods which are believed to be critical to Steller sea lions. Opportunistic sightings of Steller sea lions (sightings reported ancillary to other activities, such as surveys for Other Species, fishing, or shipping) indicate that Steller sea lions occur in offshore areas where protective measures designed to reduce fishing and sea lion interactions have not been instituted (POP 1997). The potential for competitive interaction between groundfish fisheries and Steller sea lions exists in areas that are not managed with seasonal or spatial fishery closures yet where Steller sea lions are known to occur. Under the baseline conditions, such potential interactions are thought to be reduced by overall groundfish harvest limits, also referred to as "global controls." Additionally, groundfish fisheries have been dispersed in time and space under the baseline conditions, such that the competitive interactions with Steller sea lions are thought to be mitigated to a level that is not expected to appreciably reduce the likelihood of survival and recovery of the western population of Steller sea lions.

Spatial and temporal fishing measures in FMP 2.1 deviate from the baseline in that closure areas established for the protection of environmental components other than with the objective to protect Steller sea lions are repealed. Opening up these areas reduces the protection of prey resources in nearshore areas which have been shown to be used by foraging Steller sea lions. Such openings could plausibly result in adverse impacts to Steller sea lions due to removal of fish in these areas where harvest did not occur under the baseline condition. Significantly higher harvest levels of Steller sea lion prey species are expected to result under FMP 2.1, which would increase the potential for competitive interactions with Steller sea lions in offshore foraging areas where Steller sea lion/fishery interactions are reduced through lower overall harvest limits

under the baseline condition. Thus the effects of the spatial/temporal concentration of the fisheries under FMP 2.1 are determined to be significantly adverse to the western population of Steller sea lions.

Disturbance

FMP 2.1 repeals closure areas established for the protection of environmental components other than Steller sea lions such as the Pribilof Islands habitat conservation area, the walrus protection area, salmon, herring, and crab savings areas, and certain areas that were closed to trawling under the baseline. Increased harvest levels expected to occur under FMP 2.1 may result in increased disturbance to Steller sea lions. Disturbance to Steller sea lions may increase due to the increase in the amount of fishable area coupled with increases in TAC. The level of increased disturbance to Steller sea lions, though likely, cannot be estimated, and is therefore determined to result in conditionally significantly adverse effects if disturbance were to increase to a level where population level effects would be a likely result.

Cumulative Effects

The past/present effects on the Steller sea lion are described in Section 3.8.1 (Table 3.8-1) and the predicted direct/indirect effects of the groundfish fishery under FMP 2.1 are described above (Table 4.6-5). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.6-1).

Mortality

- **Direct/Indirect Effects.** The estimated annual incidental take of Steller sea lions under FMP 2.1 in all areas of the BSAI and GOA combined is expected to be less than 14 based on expected catch under this FMP. Therefore, mortality from incidental take and entanglement in marine debris under FMP 2.1 is considered insignificant.

- **Persistent Past Effects.** Substantial mortality of Steller sea lions did not occur in the fisheries until after the 1950s. The take of Steller sea lions was substantial after this time with over 20,000 animals believed to have been incidentally killed in the foreign and JV groundfish fisheries from 1966 to 1988, although data from this period are not complete (Perez and Loughlin 1991). In the BSAI groundfish trawl fisheries, incidental take has declined from about 20 per year in the early 1990s to an average of 7.8 sea lions per year from 1996 to 2000. The number of Steller sea lions incidentally taken in state-managed nearshore salmon gillnet fisheries and halibut longline fisheries is estimated at 14.5 sea lions per year in the PWS drift gillnet fisheries (Wynne *et al.* 1992). It is thought that shooting used to be a significant source of mortality prior listing the Steller sea lion as endangered under the ESA. Two cases of illegal shooting were prosecuted in the Kodiak area in 1998 involving two Steller sea lions from the western stock (Angliss *et al.* 2001). The subsistence harvest of the western population has decreased over the last ten years from 547 to 171 animals per year (1992-1998) (Angliss and Lodge 2002). Commercial harvest of sea lions for hides and meat occurred prior to 1900 and likely depleted some local populations. Over a nine year period, 1963 to 1972, more than 45,000 Steller sea lion pups were taken for commercial purposes (Merrick *et al.* 1987). Predation by transient killer whales and sharks has always contributed to the natural mortality of Steller sea lions but the numbers of sea lions taken and the relative contribution of this factor to the

recent population decline and lack of recovery is currently under investigation (Matkin *et al.* 2001, Matkin *et al.* 2003, Springer *et al.* 2003).

- **Reasonable Foreseeable Future Effects.** Incidental take in the State-managed fisheries such as salmon gillnet fisheries will continue in the foreseeable future but the numbers of Steller sea lions will likely be relatively low (fewer than 10 per year). Entanglement in fishing gear and intentional shootings would also be expected to continue at a level similar to the baseline condition. Predation will continue to contribute to natural mortality but climate change and regime shifts would not be expected to have direct effects on mortality of Steller sea lions.

- **Cumulative Effects.** Effects of mortality are based on the contribution of the internal effects of the groundfish fishery and external mortality. These effects are considered significantly adverse since the overall human-caused mortality exceeds the PBR for this population and the species is listed as endangered under the ESA due to the severe decline of the species. The contribution of the groundfish fisheries is very small in comparison to the total human-caused mortality and, under the baseline conditions, has been considered to not cause jeopardy under the ESA (NMFS 2001a).

Prey Availability

- **Direct/Indirect Effects.** The combined harvest of Steller sea lion prey species under FMP 2.1 is expected to result in significantly adverse population level effects to Steller sea lions.

- **Persistent Past Effects.** Past effects on key prey species of Steller sea lions include harvest of species that are targeted or taken as bycatch by the GOA groundfish fisheries and parallel fisheries in State waters, and partial overlap with other State-managed fisheries. These species were also targeted in the past foreign and JV groundfish fisheries. There is substantial evidence that nutritional stress played an important role in the rapid decline of the western population of Steller sea lions during the late 1970s and 1980s and one hypothesis is that the combined fisheries, perhaps in conjunction with climate and oceanographic fluctuations, greatly reduced the availability of forage fish to Steller sea lions. NMFS issued a number of BiOps since 1991 that analyzed the key issue of whether the groundfish fisheries were contributing to the decline of Steller sea lion populations or causing adverse impacts to their critical habitat but most of the focus was on the western population. The most recent BiOp and EIS (NMFS 2001b and 2001c) explores this subject in great depth.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon and herring are expected to continue in future years in a generally similar manner to the baseline conditions. New fisheries in State or Federal waters are not anticipated. Climate change or regime shifts were identified as potentially having adverse effects of availability of prey but the direction or magnitude of these changes is difficult to predict. Climate-induced change has been suspected in the decline of the western population Steller sea lion.

- **Cumulative Effects.** Effects on prey availability were found to be cumulative based on both internal and external effects on prey. Based on significantly adverse internal effects on prey availability under this FMP, when added to the past effects from foreign, JV, and domestic groundfish fisheries, and the state-managed salmon and herring fisheries, the cumulative effect is considered significantly adverse.

Spatial/Temporal Effects of Harvest

- **Direct/Indirect Effects.** Spatial and temporal fishing measures in FMP 2.1 deviate from the baseline in that closure areas established for the protection of other environmental components would be reopened to fishing. Therefore, the effects of the spatial/temporal concentration of the fisheries under FMP 2.1 are determined to be significantly adverse to the western population of Steller sea lions.

- **Persistent Past Effects.** Past effects of spatial/temporal harvest of prey were identified for foreign, JV, federal and domestic groundfish fisheries and state-managed fisheries for salmon and herring. Past changes in the groundfish harvest have dispersed the fishing effort in time and space in order to minimize effects on Steller sea lions. Minimizing the competitive overlap between the fisheries and Steller sea lions is the primary focus of the Steller sea lion protection measures, which remain in effect under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** The only reasonably foreseeable future factors external to the groundfish fisheries that affect the spatial/temporal harvest of Steller sea lion prey would be the state-managed salmon and herring fisheries, which remove Steller sea lion prey during the spring and summer months. These fisheries are expected to continue to be managed in a similar manner to recent years. No new state or federal fisheries are anticipated at this time.

- **Cumulative Effects.** Effects of the spatial/temporal harvest of prey were based on both internal effects of the FMP, external effects of the groundfish fishery, and state-managed fisheries and future fisheries. The cumulative effect is considered significantly adverse based on the significantly adverse internal effects of FMP 2.1 on spatial temporal harvest of prey with the additional external effects.

Disturbance

- **Direct/Indirect Effects.** Although increased disturbance to Steller sea lions is likely, the level of that disturbance cannot be estimated and therefore, results in conditionally significant adverse effects; conditional on whether disturbance would result in population level effects.

- **Persistent Past Effects.** Past effects of disturbance were identified from foreign, JV, and domestic groundfish fisheries in the BSAI and GOA and state-managed fisheries. Past disturbances were also identified from commercial harvest, intentional shooting and subsistence harvest. General vessel traffic and disturbance to prey fields from gear have also regularly occurred in the past.

- **Reasonably Foreseeable Future External Effects.** Future disturbance was identified for state-managed salmon and herring fisheries as well as general fishing and non-fishing vessel traffic in Steller Sea lion foraging areas. Subsistence harvest was also identified as a continuing source of disturbance to Steller sea lions. Levels of external disturbance are expected to be similar to baseline conditions.

- **Cumulative Effects.** Disturbance to Steller sea lions is from both internal and external effects and is considered conditionally significant adverse. This determination is conditional on the actual location and timing of additional disturbance and whether it could increase over baseline conditions to a level where population-level effects occur.

Direct/Indirect Effects FMP 2.2

Incidental Take/Entanglement in Marine Debris

Effects do not deviate from those described under FMP 2.1 and are considered insignificant.

Fisheries Harvest of Prey Species

Under FMP 2.2, the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 69 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals, the change in the harvest of this key Steller sea lion prey species is rated significant. Please see the discussion regarding the unusually low fishing mortality rate in 2002 (which served as the comparative baseline) in Section 4.5.8.1. The harvest of EBS pollock under FMP 2.2 management regime meets the criteria of a significantly adverse impact to Steller sea lions.

The fishing mortality rate of GOA pollock is expected to decrease by an average of 13 percent under FMP 2.2. This change in F is insignificant under the FMP 2.2 scenario at the population level for Steller sea lions. Fishing mortality rates are not calculated for Aleutian Islands pollock as there is no directed Aleutian Islands pollock fishery under the baseline condition. There is no change in the projected catch of Aleutian Islands pollock between the baseline and FMP 2.2 and therefore effects of Aleutian Islands pollock harvests are deemed to be insignificant to Steller sea lions at the population level.

Under FMP 2.2, the BSAI Pacific cod fishing mortality rate is expected to increase by 28 percent which is considered significantly adverse to Steller sea lions according to the criteria established in Table 4.6-1. The GOA Pacific cod fishing mortality rate is expected to increase by 19 percent under the FMP 2.2 scenario which was determined to be insignificant to Steller sea lions at the population-level. Changes in Aleutian Islands Atka mackerel harvest are expected to be significantly adverse to Steller sea lions with a 64 percent increase in F under alternative FMP 2.2 relative to the baseline.

Little difference is expected relative to the baseline and among the alternatives for harvest of other, non-target species that are prey for Steller sea lions (e.g., cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMP alternatives were determined to be insignificant to Steller sea lions.

Ratings for harvest of individual prey species range from insignificant to significantly adverse. The combined harvest of Steller sea lion prey species under FMP 2.2 is rated significantly adverse overall (Table 4.6-5) as there are more prey species that will be adversely affected than those that will not and the overall effect on prey is likely to have population-level effects on the western population of Steller sea lions.

Spatial/Temporal Concentration of the Fishery

The effects of the spatial/temporal concentration of the fisheries under FMP 2.2 are rated insignificant to Steller sea lions as they do not deviate from the spatial/temporal measures under the baseline conditions.

Disturbance

FMP 2.2 retains the area closures contained in the comparative baseline. Disturbance of Steller sea lions under the FMP 2.2 management regime is not expected to increase relative to the baseline and is therefore rated insignificant.

Cumulative Effects

The past/present effects on the western population of Steller sea lions are described in Section 3.8.1 (Table 3.8-1) and the predicted direct/indirect effects of the groundfish fishery under FMP 2.2 are described above (Table 4.6-5). The effects considered in this analysis are listed in Table 4.6-5. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Effects of incidental take and entanglement under FMP 2.2 for the western population of the Steller sea lion are insignificant as discussed under FMP 2.1.

- **Persistent Past Effects.** Persistent past effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effects of mortality on the western population of the Steller sea lion are significantly adverse as described under FMP 2.1.

Prey Availability

- **Direct/Indirect Effects.** Effects on prey availability under FMP 2.2 for the western population of the Steller sea lion would be significantly adverse as discussed under FMP 2.1.

- **Persistent Past Effects.** Persistent past effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effects of prey availability on the western population of the Steller sea lion are significantly adverse as described under FMP 2.1.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effects.** Effects of spatial/temporal concentration of the fisheries under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effect of the spatial/temporal harvest of prey is based on past and future effects of the groundfish fisheries and State-managed fisheries and is considered conditionally significant adverse. Although there are several hypotheses regarding the decline and lack of recovery of Steller sea lions, localized depletion of prey due to commercial fishing is a plausible mechanism for population level effects. This rating is conditional based on the uncertainty of whether future harvests from all fisheries will combine to cause localized depletion of prey in key areas such that the western population of the Steller sea lion continues to decline or is delayed in its recovery.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the western population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** Disturbance to Steller sea lions both internal and external effects is considered insignificant because it is similar to the baseline condition, and population-level effects are unlikely.

4.6.8.2 Eastern Distinct Population Segment of Steller Sea Lions

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

With regard to incidental take, FMP 2.1 is not likely to result in significant changes to the population trajectory of the eastern distinct population segment (eastern population) of Steller sea lions. No Steller sea lions from the eastern population have been taken incidental to groundfish fisheries from 1995 to 1999 (Angliss *et al.* 2001) (Table 4.5-60). In this context, incidental take refers to animals which are deceased or have injuries that are expected to result in the death of the animal. Because no animals from the eastern population have been taken incidental to groundfish fisheries under the baseline conditions, increases in fishing effort under FMP 2.1 are not expected to result in a substantial increase in the level of incidental takes.

Entanglement of Steller sea lions from the eastern population in derelict fishing gear or other materials seems to occur at frequencies that do not have significant effects upon or represent a significant threat to the population. In conclusion, incidental take and entanglement in marine debris under FMP 2.1 are expected

to be similar to the baseline conditions and are considered insignificant according to the criteria set for significance (Table 4.1-6).

Fisheries Harvest of Prey Species

The BSAI groundfish fisheries are not likely to have large impacts on prey availability for the eastern population of Steller sea lions as there is little overlap between this population and fisheries that harvest Steller sea lion prey species. Only fisheries in the GOA would be expected to have an effect on the eastern population of Steller sea lions. Average fishing mortality rates of GOA pollock and Pacific cod under FMP 2.1 are expected to increase by 100 percent and 64 percent, respectively, relative to the comparative baseline over the next five years. The changes in the fishing mortality rates expected to occur under FMP 2.1 are rated significantly adverse at the population level for the eastern population of Steller sea lions.

Little difference is expected relative to the baseline and among the alternatives for harvest of other, non-target species that are prey for Steller sea lions (e.g. cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMPs were determined to be insignificant to Steller sea lions. The combined harvest of Steller sea lion prey species in the GOA under FMP 2.1 is expected to result in significantly adverse population level effects on the eastern population of Steller sea lions (Table 4.6-5).

Spatial/Temporal Concentration of the Fishery

The criteria used to evaluate the spatial/temporal effects of the groundfish fisheries on marine mammal populations assume that the FMP would be expected to result in either increased or decreased spatial/temporal concentrations in key marine mammal foraging areas and periods such that prey resources are altered to the extent that population level effects would occur. The spatial/temporal measures under the baseline conditions were designed with the objective of reducing competitive interactions between groundfish fisheries and Steller sea lions in their key foraging areas during periods which are believed to be critical to Steller sea lions. Under the baseline condition, groundfish fisheries have been dispersed in time and space such that the competitive interactions with Steller sea lions are thought to be mitigated to an insignificant level. Spatial and temporal fishing measures in FMP 2.1 deviate from the baseline in that closure areas established for the protection of environmental components other than Steller sea lions are repealed. Opening up these areas reduces the protection of prey resources in nearshore areas that have been shown to be used by foraging Steller sea lions and could plausibly result in adverse impacts to Steller sea lions due to removal of fish in these areas where harvest did not occur under the baseline condition. Thus, the effects of the spatial/temporal concentration of the fisheries under FMP 2.1 are determined to be conditionally significant adverse to Steller sea lions, contingent on the actual concentration of the fisheries reducing prey to a level that results in a population-level effect.

Disturbance

FMP 2.1 repeals closure areas established for the protection of environmental components other than Steller sea lions such as the Pribiliof Islands habitat conservation area, the walrus protection area, salmon, herring, and crab savings areas, and certain areas that were closed to trawling under the baseline. The area that is of specific concern for the eastern population of Steller sea lions under FMP 2.1 is the trawl exclusion zone in the eastern GOA which would be open to trawling under this FMP. Disturbance of the eastern population of Steller sea lions is expected to increase under the FMP 2.1 management regime if trawling activity occurs

in this previously closed area. Catch of fishery target species is also projected to increase under FMP 2.1 relative to the baseline. Coupled with the expansion of the fishery into new areas and an overall increase in fishing pressure, disturbance of animals under FMP 2.1 may increase above the baseline conditions to the level that population level effects could occur and is therefore determined to be conditionally significant adverse to the eastern population of Steller sea lions.

Cumulative Effects

The past/present effects on the eastern population of the Steller sea lion are described in Section 3.8.1 (Table 3.8-1) and the predicted direct/indirect effects of the groundfish fishery under FMP 2.1are described above (Table 4.6-5). The effects considered in this analysis are listed in Table 4.6-5. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.6-1).

Mortality

- **Direct/Indirect Effect.** With regard to incidental take and entanglement, FMP 2.1 is not likely to result in significant changes to the population trajectory of the eastern population of Steller sea lions, and is therefore considered insignificant.

- **Persistent Past Effects.** It is thought that shooting used to be a significant source of mortality prior to listing the Steller sea lion as "threatened" under the ESA. NMFS Alaska Enforcement Division has successfully prosecuted two cases of illegal shooting involving four sea lions from the eastern population (Angliss *et al.* 2001). It is not known to what extent illegal shooting continues in the eastern population but stranding of sea lions with bullet holes still occurs. Predator control programs associated with mariculture facilities in British Columbia account for a mean of 44 animals killed per year from the eastern population (Angliss and Lodge 2002). The subsistence harvest of the eastern population is subject to an average of only two sea lions taken per year from southeast Alaska (1992 to 1997) (Angliss *et al.* 2001). Commercial harvest of sea lions for hides and meat occurred prior to 1900 and likely depleted local populations. Over a nine year period, 1963 to 1972, more than 45,000 Steller sea lion pups were taken for commercial purposes (Merrick *et al.* 1987). The proportion of these from the eastern population of Steller sea lions is unknown. Intentional shooting of Steller sea lions, other than in subsistence hunts, became illegal after the species was listed as threatened under the ESA in 1990. It is thought that shooting was a significant source of mortality prior to that time. Steller sea lions are incidentally taken in low numbers by commercial fisheries other than groundfish fisheries, including some state-managed salmon drift and set gillnet fisheries, and the salmon troll fishery in southeast Alaska (mean of 1.25 and 0.2 respectively) (Angliss and Lodge 2002). Small numbers of Steller sea lions from the eastern population are also taken outside of southeast Alaska in groundfish fisheries (0.45 per year in Washington, Oregon, and California) and set gillnet fisheries in Northern Washington state (0.2 per year) (Angliss and Lodge 2002). The PBR for this population is 1,396 and current human caused mortality is 45.5, substantially less than 10 percent of the PBR.

- **Reasonably Foreseeable Future External Effects.** Incidental take in the state-managed fisheries such as salmon gillnet and troll fisheries will continue in the foreseeable future but the numbers of Steller sea lions will likely be relatively low (<10 per year). Groundfish fisheries in Washington, Oregon and California and salmon set gillnet fisheries will continue to take small numbers from this

population. Entanglement and intentional shootings would also be expected to continue. Pollution is likely more of a factor for this population due to its proximity to human population centers. Climate change and regime shifts would not be expected to have direct effects on mortality of Steller sea lions.

- **Cumulative Effects.** Effects of mortality are based on the contribution of internal effect of the groundfish fishery and external mortality effects. These effects are considered insignificant since the overall human-caused mortality does not exceed the PBR for this population. Although this population is listed as threatened under the ESA, this population has been increasing over the last 20 years. The contribution of the groundfish fisheries is very small in comparison to the total human-caused mortality and has been determined to not cause jeopardy under the ESA (NMFS 2001a).

Effects of Prey Availability

- **Direct/Indirect Effect.** Due to major increases in the projected harvest of target and non-target species under FMP 2.1, the effect on prey availability was determined to be significantly adverse to Steller sea lions.

- **Persistent Past Effects.** Past effects on key prey species of Steller sea lions include harvest of species that are targeted or taken as bycatch by the GOA groundfish fisheries and parallel fisheries in state waters, and partial overlap with other state-managed fisheries. These species were also targeted in the past foreign and JV groundfish fisheries.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries such as salmon and herring are expected to continue in future years in a similar manner to the baseline condition. New fisheries in state or federal waters are not anticipated. Climate change or regime shifts were identified as potentially having adverse effects on availability of prey but the direction or magnitude of these changes is difficult to predict. Climate induced change has been suspected in the decline of the western population Steller sea lion, but effects of climate change or regime shifts on the eastern population of the Steller sea lion are largely unknown.

- **Cumulative Effects.** Effects on prey availability were found to be cumulative based on both internal and external effects on prey. The significantly adverse contribution of the groundfish fishery under FMP 2.1 may or may not lead to adverse population level effects, conditional on whether future food availability limits population growth. The cumulative effect is thus considered conditionally significant adverse.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** Spatial and temporal fishing measures in FMP 2.1 deviate from the baseline in that closure areas established for the protection of other environmental components would be reopened to fishing. The effects of the spatial/temporal concentration of the fisheries under FMP 2.1 are determined to be conditionally significant adverse to the eastern population of Steller sea lions.

- **Persistent Past Effects.** Past effects of spatial/temporal harvest of prey were identified for foreign, JV, federal and domestic groundfish fisheries and state-managed fisheries for salmon and herring.

Past changes in the groundfish harvest have dispersed the fishing effort in time and space in order to minimize effects on Steller sea lions. Minimizing the competitive overlap between the fisheries and Steller sea lions is the primary focus of the Steller sea lion protection measures, which remain in effect under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** The only reasonably foreseeable future factors external to the groundfish fisheries that affect the spatial/temporal harvest of Steller sea lion prey would be the state-managed salmon and herring fisheries, which remove Steller sea lion prey during the spring and summer months. These fisheries are expected to continue to be managed in a similar manner to recent years. No new state or federal fisheries are anticipated at this time.

- **Cumulative Effects.** Cumulative effects of the spatial/temporal harvest of prey from both internal effects of the groundfish fishery and state-managed fisheries would be substantially greater than the baseline condition and are considered conditionally significant adverse. This rating is conditional on whether the combined spatial/temporal patterns of prey removal from all fisheries in the range of the eastern population of Steller sea lions actually creates localized depletion of prey such that adverse population level effects occur.

Disturbance

- **Direct/Indirect Effects.** Disturbance of Steller sea lions under FMP 2.1 may increase substantially above the baseline conditions and is therefore determined to be conditionally significant adverse. This rating is conditional on whether changes in disturbance patterns would actually result in population level effects.

- **Persistent Past Effects.** Past effects of disturbance were identified from foreign, JV, and domestic groundfish fisheries in the BSAI and GOA and State-managed fisheries. Past disturbances were also identified from commercial harvest, intentional shooting and subsistence harvest. General vessel traffic and disturbance to prey fields from gear have also regularly occurred in the past.

- **Reasonably Foreseeable Future External Effects.** Future disturbance was identified for state-managed salmon and herring fisheries as well as general fishing and non-fishing vessel traffic in Steller Sea lion foraging areas. Subsistence harvest was also identified as a continuing source of disturbance to Steller sea lions. Levels of external disturbance are expected to be similar to baseline conditions.

- **Cumulative Effects.** The cumulative effects of disturbance to the eastern population of Steller sea lions from both internal and external effects are considered conditionally significant adverse, conditional on location and time period of additional disturbance and whether it would result in population-level effects.

Direct/Indirect Effects FMP 2.2

Incidental Take/Entanglement in Marine Debris

Effects do not deviate from those described under FMP 2.1 and are considered insignificant.

Fisheries Harvest of Prey Species

Average fishing mortality rates of GOA pollock under FMP 2.2 are expected to decrease by 13 percent relative to the comparative baseline over the next five years. Average fishing mortality rates of GOA Pacific cod under FMP 2.2 are expected to increase by 19 percent relative to the comparative baseline over the next five years. The changes in the fishing mortality rates expected to occur under FMP 2.2 are insignificant relative to the baseline for GOA pollock and Pacific cod harvests.

Little difference is expected relative to the baseline and among the alternatives for harvest of other, non-target species that are prey for Steller sea lions (e.g. cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMP alternatives were determined to be insignificant to Steller sea lions. The combined harvest of Steller sea lion prey species under FMP 2.2 is expected to be similar to the baseline condition and to insignificant effects on the eastern population of Steller sea lions.

Spatial/Temporal Concentration of the Fishery

The effects of the spatial/temporal concentration of the fisheries under FMP 2.2 are determined to be insignificant to Steller sea lions as they do not deviate from the spatial/temporal measures under the baseline condition.

Disturbance

FMP 2.2 retains the area closures set forth under the baseline. Disturbance of Steller sea lions under the 2.2 management regime is not expected to increase relative to the baseline and is therefore rated insignificant.

Cumulative Effects

The past/present effects on the eastern population of Steller sea lions in southeast Alaska are described in Section 3.8.1 (Table 3.8-1). Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Effects of incidental take and entanglement under FMP 2.2 for the eastern population of the Steller sea lion would be insignificant.

- **Persistent Past Effects.** Persistent past effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effect of mortality on the eastern population of the Steller sea lion would be insignificant, as described under FMP 2.1.

Prey Availability

- **Direct/Indirect Effects.** The combined harvest of Steller sea lion prey species under FMP 2.2 is expected to result in insignificant population-level effects on Steller sea lions.

- **Persistent Past Effects.** Persistent past effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** Effects on prey availability are based on both internal and external effects on prey but since the eastern population has been increasing over the last 20 years, the availability of prey is not considered a major issue with this population. The cumulative effects are not expected to result in population-level effects and are considered insignificant for this population in southeast Alaska.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effects.** Effects of spatial/temporal concentration of the fisheries under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** Cumulative effects of the spatial/temporal concentration of harvest of prey from internal past effects of the groundfish fishery and state-managed fisheries are likely to remain similar to the baseline condition, under which the eastern population has increased steadily, and is therefore considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the eastern population of the Steller sea lion are the same as described under FMP 2.1.

- **Cumulative Effects.** Disturbance to Steller sea lions from both internal and external effects is considered insignificant because it is similar to the baseline condition, and population-level effects are unlikely.

4.6.8.3 Northern Fur Seals

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

According to projected catch levels, takes and entanglements of northern fur seals expected to occur incidental to groundfish fisheries under FMP 2.1 are not expected to result in population level effects. Increased harvest rates under this management alternative are not large enough for expected take levels to increase relative to the baseline. Therefore, this effect is expected to be insignificant under FMP 2.1.

Fisheries Harvest of Prey Species

Under FMP 2.1, the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 140 percent relative to the comparative baseline. This change in the harvest of adult pollock, which is a key prey species of northern fur seals in the EBS, is rated significantly adverse. Various nearshore areas that were closed under the baseline conditions would be repealed in FMP 2.1. Opening these nearshore areas could potentially result in a shift in the species and age composition of groundfish harvests such that prey species of northern fur seals would be more susceptible to harvest under this management regime relative to the baseline conditions. Therefore, the harvest of northern fur seal prey species was determined to be conditionally significant adverse. Population level effects are plausible but the rating is conditional on whether the increased level of pollock harvest under FMP 2.1 results in limited prey resources and if the fishery further encroaches into nearshore fur seal foraging areas in the groundfish fisheries.

Spatial/Temporal Concentration of the Fishery

The criterion used to evaluate the spatial/temporal effects of the groundfish fisheries on marine mammal populations is that the alternative FMP would be expected to result in either increased or decreased spatial/temporal concentrations in key marine mammal foraging areas and periods such that prey resources are altered to the extent that population level effects would be expected to occur. Spatial and temporal fishing measures in FMP 2.1 deviate from the baseline in that closure areas established for the protection of environmental components other than Steller sea lions are repealed. Opening these areas to fishing may reduce the protection of prey resources in nearshore areas that have been shown to be used by foraging northern fur seals and could plausibly result in adverse impacts to northern fur seals due to removal of fish in these areas where harvest did not occur under the baseline conditions. FMP 2.1 is less precautionary for northern fur seals as areas such as the Pribilof Habitat Conservation area would be open to fishing. The effect on northern fur seals of fishing in these areas that were closed under the baseline is unknown. In addition to an overall projected increase in harvest of adult pollock under FMP 2.1, harvest of juvenile target species that are a large portion of the northern fur seal diet may increase if fisheries were to move into these nearshore areas. Such harvests are likely to have a greater effect on the species than harvest under the baseline conditions. Thus the effects of the spatial/temporal concentration of the fisheries under FMP 2.1 are rated conditionally significantly adverse to northern fur seals. The rating is conditional based on whether repeal of baseline protection measures actually increases concentration of harvest in fur seal foraging areas and such harvest has population-level effects.

Disturbance

The potential for disturbance effects caused by vessel traffic, fishing gear or noise appears limited for northern fur seals. Kajimura (1984) (in Johnson *et al.* 1989) reported no response by fur seals when approached by ships, and NOAA Fisheries observers onboard Japanese driftnet vessels regularly reported fur seals in close proximity to both the gear and fishing vessels (INPFC reports from the 1980s). Interactions with other types of fishing gear, such as trawl nets, also appear to be limited, based on the rare incidence of takes in groundfish fisheries and limited overlap between northern fur seal prey preferences and fisheries targets.

The FMP 2.1 bookend repeals closure areas established for the protection of environmental components other than Steller sea lions such as the Pribiliof Islands habitat conservation area, the walrus protection area, salmon, herring, and crab savings areas, and certain areas that were closed to trawling under the baseline. Disturbance of northern fur seals is expected to increase under the FMP 2.1 management regime if trawling activity occurs in this previously closed area. Coupled with the expansion of the fishery into new areas and an overall increase in fishing pressure, disturbance of animals under FMP 2.1 may increase to the level that population level effects could occur and is, therefore, determined to be conditionally significant adverse to northern fur seals. The rating is conditional based on whether disturbance increases substantially around fur seal rookeries in the Pribilof Islands and whether it actually causes population-level effects.

Cumulative Effects

A summary of the effects of the past/present with regards to the northern fur seal is presented in Section 3.8.2. (Table 3.8-2). The predicted direct/indirect effects of the groundfish fishery under FMP 2.1 are described above (Table 4.6-5). Representative direct effects used in this analysis include mortality and disturbance. Indirect effects include availability of prey and spatial/temporal concentration of the fisheries (Table 4.6-5).

Mortality

- **Direct/Indirect Effects.** Under FMP 2.1, effects of incidental take and entanglement are not expected to have population-level effects and are considered insignificant.

- **Persistent Past Effects.** Effects of past mortality on fur seal population include commercial harvest of young males up to 1985, harvest of females between 1956 and 1968, incidental take in the JV fisheries, foreign fisheries, and annual subsistence harvest on the Pribilof Islands. Commercial harvest of fur seals peaked in 1961 with over 126,000 animals but was halted in 1985. The harvest of female fur seal on the Pribilof Islands, as many as 300,000 between 1956 and 1968, likely contributed to the decline of the population in the late 1970s and early 1980s (York and Kozloff 1987). This precipitous decline resulted in its depleted status under the MMPA. Entanglements may have contributed significantly to declining trends of the population during the late 1970's (Fowler 1987). Since the cessation of commercial harvest in 1985, fur seal number have steadily declined (NMFS 1993, Angliss and Lodge 2002). The contribution of the earlier harvest of fur seal to the subsequent declines uncertain since it has been nearly 20 years since commercial harvest was ended. Subsistence harvest have been one of the major contributors to fur seal mortality in recent years. From 1986 to 1996, the average annual subsistence take was 1,605 from St. Paul and St. George

Islands. From 1995 to 2000 this average take dropped to 1,340 seals per year, which represents about 8 percent of the PBR for this species.

- **Reasonably Foreseeable Future External Effects.** These effects include incidental take from foreign fisheries outside the EEZ where fur seals are widely dispersed. State-managed fisheries take small numbers of fur seal including the PWS drift gillnet fishery, Alaska Peninsula and Aleutian Island salmon gillnet fisheries, and the Bristol Bay salmon fisheries (Angliss and Lodge 2002). Subsistence will continue to be a major source of mortality in the future but is limited to the Pribilof Islands, but levels of take are expected to be well below 10 percent of the PBR for this species.

- **Cumulative Effects.** The cumulative effects of mortality from internal and external factors are considered insignificant because the expected levels of take for fur seals would be well below the PBR of this species. The contribution of the groundfish fisheries is very small and approaches zero. Thus, population level effects are not anticipated.

Availability of Prey

- **Direct/Indirect Effects.** The effects of the groundfish fisheries under FMP 2.1 include a substantial increase in the removal of northern fur seal forage. The overall harvest of northern fur seal prey species is rated as conditionally significant adverse.

- **Persistent Past Effects.** Effects of groundfish harvest in the past have likely occurred from overlap of prey species and fish targeted by the foreign and JV fisheries in the BSAI as well as by the State and Federal fisheries. Climate and oceanic fluctuations are also suspected in past changes in the abundance and distribution of prey.

- **Reasonably Foreseeable Future External Effects.** Effects on prey availability for northern fur seal in the future are anticipated to come from a small overlap in prey species with the State-managed salmon and herring fisheries in nearshore areas and effects of climate change/regime shifts on prey species abundance and distribution. Climate effects are largely unknown but could potentially have adverse effects on the availability of prey.

- **Cumulative Effects.** The cumulative effect of prey availability from both the internal contribution of the groundfish fisheries and external effects on prey such as other fisheries and possibly long-term climate change is considered conditionally significant adverse. This rating is based on the fact that the population declined substantially in the past for unknown reasons and that decreased prey availability is a plausible mechanism that could have contributed to the decline. Since the causal link between the population decline and the cumulative effects of all past fisheries on prey availability has not been established, the potentially adverse cumulative effects on northern fur seal through this mechanism are considered conditional.

Spatial/Temporal Concentration of Harvest

- **Direct/Indirect Effect.** Effects of groundfish fisheries under FMP 2.1 on the spatial/temporal concentration of fisheries harvest are a substantial departure from the baseline conditions and are thus determined to be conditionally significant adverse.

- **Persistent Past Effect.** Effects of past fisheries harvest on prey are primarily from the foreign and JV fisheries and the BSAI state and federal domestic fisheries. There has been concern with regard to displaced/increased fishing effort that encroaches into nearshore areas of the Pribilof Islands and results in increased overlap with fur seal foraging areas. After adoption of measures designed to protect Steller sea lions, the proportion of the total June-October pollock catch in fur seal foraging habitat increased from an average of 40 percent in 1995-1998 to 69 percent in 1999-2000 (NMFS 2001b). There is particular concern for the potential impact of this increased fishing pressure on lactating females from St George Island where catch rates were consistently higher than in areas used by females from St. Paul (Robson *et al.* 2004).

- **Reasonably Foreseeable Future External Effects.** Effects of the spatial/temporal harvest of prey species is primarily from the foreign and Federal domestic fisheries outside the EEZ, due to the extensive range of the fur seals when they are away from their breeding rookeries. State-managed fisheries have very limited overlap with fur seal prey. Climate change was also identified as a potential factor in spatial/temporal effects on prey.

- **Cumulative Effects.** The cumulative effects of the spatial/temporal harvest of prey resulting from internal and external sources are considered conditionally significant adverse. This rating is based on the substantial decline in northern fur seal populations and is conditional on the actual contribution that the harvest of prey species plays in this declining trend.

Disturbance

- **Direct/Indirect Effects.** Levels of disturbance are expected to be substantially greater than those which occurred to northern fur seals under the baseline conditions and could potentially have population-level effects that are expected to be conditionally significant adverse.

- **Persistent Past Effects.** Past disturbance of fur seals includes commercial groundfish fisheries harvest by JV fisheries, foreign and federal domestic fisheries, state-managed fisheries and, to a lesser extent, the subsistence harvest of fur seal on the Pribilof Islands. It is unlikely that disturbance persists as a result of these past activities but the ongoing fisheries do continue to result in some level of disturbance to fur seal while they are in the BSAI region.

- **Reasonablely Foreseeable Future Effects.** Disturbance effects on fur seal were identified from state-managed fisheries, general vessel traffic, and subsistence activities on the Pribilof Islands.

- **Cumulative Effects.** The cumulative effects of disturbance were determined to be conditionally significant adverse based on the conditionally significant internal effects of the fisheries when added to the external human-caused disturbance. This rating is conditional on the increased disturbance occurring in foraging areas important to fur seals and having a population level effect.

Direct/Indirect Effects FMP 2.2

Incidental Take/Entanglement in Marine Debris

Effects do not deviate from those described under FMP 2.1.

Fisheries Harvest of Prey Species

Under FMP 2.2 , the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 69 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals, this change in the harvest of adult pollock, which is a key prey species of northern fur seals in the EBS, is rated significantly adverse. Overall, the harvest of northern fur seal prey species was determined to be conditionally significant adverse as population level effects are plausible but the rating is conditional on whether the increased level of pollock harvest projected under FMP 2.2 results in limited prey resources such that fur seals are impacted at the population level.

Spatial/Temporal Concentration of the Fishery

The effects of the spatial/temporal concentration of the fisheries under FMP 2.2 are determined to be insignificant to northern fur seals as they do not deviate from the spatial/temporal measures under the baseline conditions. However, effects to northern fur seals from spatial/temporal concentration of the fisheries under the strategy defined as the baseline for this environmental analysis were rated conditionally significant adverse in the Steller sea lion SEIS (NMFS 2001b). Therefore, while the spatial/temporal effects of FMP 2.2 are insignificant relative to the baseline, the baseline has been described as having potential adverse effects on northern fur seals.

Disturbance

Disturbance of northern fur seals under the FMP 2.2 management regime is not expected to increase relative to the baseline and is therefore considered insignificant.

Cumulative Effects

The past/present effects on the northern fur seal are described in Section 3.8.2 (Table 3.8-2). Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6). See Table 4.6-5 for a summary of the cumulative effects under FMP 2.2.

Mortality

- **Direct/Indirect Effects.** Under FMP 2.2, effects of incidental take and entanglement are not expected to have population-level effects and are considered insignificant.

- **Persistent Past Effects.** Persistent past effects on northern fur seals are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on northern fur seals are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effects of mortality from internal and external factors are considered insignificant because the expected levels of take for fur seals would be below the PBR of this species. The contribution of the groundfish fisheries is very small and approaches zero. Thus, population level effects are not anticipated.

Prey Availability

- **Direct/Indirect Effects.** The combined harvest of northen fur seal prey species under FMP 2.2 is expected to result in conditionally significant adverse population-level effects on northern fur seal.

- **Persistent Past Effects.** Persistent past effects on the northern fur seal are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the northern fur seal are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effects of prey availability from the internal contribution of the groundfish fisheries and external effects on prey from other fisheries and possibly long-term climate change are conditionally significant adverse. This rating is based on the fact that the population declined substantially in the past for unknown reasons and that decreased prey availability is a plausible mechanism that could have contributed to the decline. Since the causal link between the population decline and the cumulative effects of all past fisheries on prey availability has not been established, the potentially adverse cumulative effects on northern fur seal through this mechanism are considered conditional.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effects.** Effects of spatial/temporal concentration of the fisheries under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the northern fur seal are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the northern fur seal are the same as described under FMP 2.1.

- **Cumulative Effects.** Cumulative effects of the spatial/temporal harvest of prey from internal and external sources are conditionally significant adverse. This rating is based on the fact that the population declined substantially in the past for unknown reasons and that localized depletion of prey is a plausible mechanism that could have contributed to the decline. Since the causal link between the population decline and the cumulative effects of all past fisheries on localized depletion of prey has not been established, the potentially adverse cumulative effects on northern fur seal through this mechanism are considered conditional.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the northern fur seal are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the northern fur seal are the same as described under FMP 2.1.

- **Cumulative Effects.** Cumulative effects of disturbance to northern fur seals from both internal and external effects are considered insignificant because these effects are similar to the baseline condition and population-level effects are unlikely.

4.6.8.4 Harbor Seals

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

According to projected catch levels, incidental takes and entanglements of harbor seals expected to occur incidental to groundfish fisheries under FMP 2.1 are not expected to result in population level effects. Increased harvest rates under this management alternative may result in the increased take of 2 harbor seals relative to the baseline, for a total estimated average of fewer than 7 animals per year. This level of incidental take would not result in changes to the population trajectory for this species. Therefore, takes and entanglements of harbor seals incidental to groundfish fisheries are determined to be insignificant according to the criteria established in Table 4.1-6.

Fisheries Harvest of Prey Species

Under FMP 2.1, the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 140 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals, the change in the harvest of this key harbor seal prey species is considered to be significant. See the discussion regarding the unusually low fishing mortality rate of EBS pollock in 2002 in Section 4.5.8.1. The harvest of EBS pollock under the FMP 2.1 management regime meets the criteria of a significantly adverse impact to harbor seals.

The fishing mortality rate of GOA pollock is expected to increase by an average of 100 percent under FMP 2.1 relative to the comparative baseline over the next 5 years. The change in F is significant at the population level for harbor seals under the 2.1 scenario. Under Alternative bookend 2.1, the BSAI Pacific cod fishing mortality rate is expected to increase by 79 percent, which is determined to be significantly adverse to harbor seals according to the criteria established in Table 4.1-6. Changes in Aleutian Islands Atka mackerel harvest under FMP 2.1 are expected to be significantly adverse to harbor seals with a 124 percent increase in F relative to the baseline.

Little difference is expected relative to the baseline and among the alternatives for harvest of other, non-target species that are prey for harbor seals (e.g., cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMP alternatives were determined to be insignificant to harbor seals. The combined harvest of harbor seal prey species under FMP 2.1 is expected to be substantially above the baseline level and thus result in significantly adverse population level effects.

Spatial/Temporal Concentration of the Fishery

Spatial and temporal fishing measures in FMP 2.1 deviate from the baseline in that closure areas established for the protection of environmental components other than Steller sea lions would be repealed. Spatial partitioning of offshore commercial harvests from the Steller sea lion conservation measures and inshore feeding harbor seals is likely to limit the degree of potential competition with fisheries, although the foraging range of harbor seals may still overlap commercial fishing grounds. Such overlaps exist in regard to the western and GOA harbor seal stocks whereas the southeast Alaska stock of harbor seals overlaps little with federally managed commercial groundfish fisheries (Ferrero *et al.* 2000). However, repealing trawl closure areas in southeast Alaska would be expected to result in increased overlap between groundfish fisheries and the southeast Alaska harbor seal stock. Opening up these areas reduces the protection of prey resources in nearshore areas that have been shown to be used by foraging harbor seals and could plausibly result in adverse impacts to harbor seals due to removal of fish in these areas where harvest did not occur under the baseline conditions. Thus the effects of the spatial/temporal concentration of the fisheries under FMP 2.1 are rated conditionally significantly adverse to harbor seals.

Disturbance

Disturbance of harbor seals is expected to increase under the FMP 2.1 management regime if trawling activity occurs in previously closed areas. Catch of fishery target species is also projected to increase under FMP 2.1 relative to the baseline. Coupled with the expansion of the fishery into new areas and an overall increase in fishing pressure, disturbance of animals under FMP 2.1 may increase to the level that population-level effects could occur and is determined to be conditionally significant adverse to harbor seals.

Cumulative Effects

A summary of the effects of the past/present with regards to the harbor seal is presented in Section 3.8.4. (Table 3.8-4). The predicted direct/indirect effects of the groundfish fishery under FMP 2.1 are described above (Table 4.6-5). Representative direct effects used in this analysis include mortality and disturbance. Indirect effects include availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Takes and entanglements of harbor seals expected to occur incidental to groundfish fisheries under FMP 2.1 are not expected to result in population level effects, and therefore are considered to be insignificant.

- **Persistent Past Effect.** Residual effect on local populations of State predator control programs (1950s to 1972) and commercial hunts (1963 to 1972) may still occur in some areas although there are no data on these factors. Foreign and JV groundfish fisheries in the 1960s and 1970s have likely contributed to some level of direct harbor seal mortality from entanglement in gear, but based on the near shore distribution of harbor seals, there was likely minimal direct interaction, and mortality is believed to have been very low. From 1990 to 1996, minimum estimates of harbor seals taken incidentally in groundfish gear in the Bering Sea were 4 per year and fewer than 1 per year in the GOA. In southeast Alaska, 4 harbors seals are estimated to be killed each year on longlines. Harvest of harbor seals for subsistence purposes is likely the highest cause of anthropogenic mortality for this species since the cessation of commercial harvests in the early 1970s. Between 1992 and 1998,

the state-wide subsistence harvest of harbor seals from all stocks ranged between 2,546 and 2,854 animals, the majority of which were taken in southeast Alaska (Wolfe and Hutchinson-Scarbrough 1999). Subsistence harvest of Bering sea stock of harbor seals is approximately 161 animals, 42 percent of PBR for this species. For the GOA stock, the harvest is at approximately 91 percent of the PBR for this stock. For the southeast stock, harvest is at approximately 83 percent of PBR.

- **Reasonably Foreseeable Future External Effects.** Incidental take of harbor seal in state-managed fisheries such as salmon gillnet fisheries would be expected to continue at its present low rate. Subsistence take is expected to continue to be the greatest source of human-controlled mortality with a relatively high percentage of the PBR in both the GOA and southeast Alaska stock and a lower take in the BSAI region. Climate change is likely not a factor in the direct mortality of harbor seal although there would likely indirect effects.

- **Cumulative Effects.** The cumulative effects of mortality were determined to be insignificant since the combined contribution between the various sources would continue to be under the PBR for this species.

Availability of Prey

- **Direct/Indirect Effects.** The combined harvest of harbor seal prey species under FMP 2.1 is expected to be much greater than the baseline level and result in significantly adverse effects on prey availability.

- **Persistent Past Effects.** Availability of prey for harbor seal in the past has likely been affected by foreign and JV fisheries, federal domestic groundfish fisheries and state-managed salmon and herring fisheries since the fish targeted by these fisheries are also prey of the harbor seal. Climate change/regime shift could possibly have been a factor in fluctuations in prey availability in the past.

- **Reasonably Foreseeable Future External Effects.** State-managed salmon and herring fisheries are identified as potential adverse effects on harbor seal prey availability. Climate change/regime shift will continued to be a contributing factor although the effects can be either beneficial or adverse, depending on direction and magnitude of the change.

- **Cumulative Effects.** The cumulative effect on prey availability was determined to be significantly adverse based on a significant internal effect and the additional contribution of external effects and is likely to have a population-level effect on harbor seals.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** The effects of the spatial/temporal concentration of the fisheries under FMP 2.1 are rated conditionally significantly adverse to harbor seals.

- **Persistent Past Effects.** Effect of groundfish harvest in the past has likely occurred from overlap of harbor seal prey species and fish targeted and areas fished by the foreign and JV fisheries in the BSAI as well as the State and Federal fisheries.

- **Reasonably Foreseeable Future External Effects.** Future effect on spatial/temporal harvest is considered to come from the competitive overlap in prey species with the state-managed fisheries in nearshore areas such as salmon and herring and from climate change/regime shifts on prey species abundance and distribution. Since these fisheries generally occur in the nearshore areas in comparsion to groundfish fisheries, overlap is more pronounced than with the groundfish fisheries.

- **Cumulative Effects.** A cumulative effect of spatial/temporal harvest of prey is identified and rated as conditionally significant adverse, based on the increased level of harvest of harbor seal prey species, fishing areas newly opened, contribution from state-managed fisheries, and conditional on prey being substantially less available and resulting in a population-level effect.

Disturbance

- **Direct/Indirect Effect.** Disturbance of animals under FMP 2.1 may increase to the level that population-level effects could occur and is determined to be conditionally significant adverse to harbor seals.

- **Persistent Past Effects.** Disturbance of harbor seals from past effects include commercial groundfish fisheries harvest by JV fisheries, foreign and federal domestic fisheries and to a lesser extent the subsistence harvest of harbor seals. It is unknown whether these past activities have persistent effects in the present but the ongoing fisheries activities and subsistence do continue to result in some level of disturbance to harbor seal.

- **Reasonablely Foreseeable Future Effects.** State-managed fisheries, general vessel traffic and subsistence activities would continue to create some level of disturbance to harbor seal in the foreseeable future.

- **Cumulative Effects.** A cumulative effect was identified for disturbance from contributions from internal sources and external factors such as other fisheries. However, since fishing effort would increase substantially under FMP 2.1, and the effects of this level of disturbance are not well understood, the cumulative effect on harbor seal is considered conditionally significant adverse, conditional on the actual locations and time period of this new disturbance.

Direct/Indirect Effects FMP 2.2

Incidental Take/Entanglement in Marine Debris

Effects do not deviate from those described under FMP 2.1 and are considered insignificant.

Fisheries Harvest of Prey Species

Under FMP 2.2 , the fishing mortality rate (F) of EBS pollock is expected to increase by an average of 69 percent relative to the comparative baseline. According to the significance criteria for effects on marine mammals the change in the harvest of this key harbor seal prey species is rated significant. See the discussion regarding the unusually low fishing mortality rate in 2002 (which served as the comparative baseline) in Section 4.5.8.1. The harvest of EBS pollock under the FMP 2.2 management regime meets the criteria of a significantly adverse impact to harbor seals.

The fishing mortality rate of GOA pollock is expected to decrease by an average of 13 percent under the FMP 2.2 bookend relative to the comparative baseline over the next 5 years. The change in F is insignificant at the population level for harbor seals under the FMP scenario. Under FMP 2.2, the BSAI Pacific cod fishing mortality rate is expected to increase by 28 percent, which is determined to be significantly adverse to harbor seals according to the criteria established in Table 4.1-6. Changes in Aleutian Islands Atka mackerel harvest under the FMP 2.2 bookend are expected to be significantly adverse to harbor seals with a 64 percent increase in F relative to the baseline.

Little difference is expected relative to the baseline and among the alternatives for harvest of other, non-target species that are prey for harbor seals (e.g. cephlapods and forage fish such as capelin). Changes in the harvest of these species under the various FMP alternatives was determined to be insignificant to harbor seals. The combined harvest of harbor seal prey species under FMP 2.2 is expected to be substantially greater than the baseline for some species but not for others, leading to a rating of conditionally significantly adverse effect on prey availability. This rating is conditional on whether harvest rates under FMP 2.2 actually deplete harbor seal prey availability to the point that population-level effects occur.

Spatial/Temporal Concentration of the Fishery

The effects of the spatial/temporal concentration of the fisheries under FMP 2.2 are determined to be insignificant to harbor seals as they do not deviate from the spatial/temporal measures under the baseline condition and are not likely to cause population level effects.

Disturbance

Disturbance of harbor seals under the FMP 2.2 management regime is not expected to increase relative to the baseline and is therefore considered to be insignificant.

Cumulative Effects

The past/present effects on the harbor seal are described in Section 3.8.4 (Table 3.8-4). Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Takes and entanglements of harbor seals expected to occur under FMP 2.2 are expected to be similar to the baseline level and are considered to be insignificant at the population level.

- **Persistent Past Effects.** Persistent past effects on the harbor seal are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the harbor seal are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effects of mortality were determined to be insignificant since the combined contribution between the various sources would continue to be under the PBR for this species.

Prey Availability

- **Direct/Indirect Effects.** The combined harvest of harbor seal prey species under FMP 2.2 is expected to result in conditionally significant adverse population-level effects on harbor seals.

- **Persistent Past Effects.** Persistent past effects on the harbor seal are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on harbor seal are same as described under FMP 2.1.

- **Cumulative Effects.** Effects on prey availability were found to be cumulative based on both internal and external effects on prey from other fisheries and possibly long-term climate change. This cumulative effect is considered conditionally significant adverse based on the internal effects of decreased availability of prey species. This rating is conditional on whether prey availability has played a role in the past population decline of harbor seals and whether future combined harvest rates actually deplete harbor seal prey availability to the point that population-level effects occur.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effects.** Effects of spatial/temporal concentration of the fisheries under FMP 2.2 are similar to the baseline and determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the harbor seal are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on the harbor seal are the same as described under FMP 2.1.

- **Cumulative Effects.** Cumulative effects on spatial/temporal harvest of prey are rated as conditionally significant adverse based on the increased level of harvest of harbor seal prey species under FMP 2.2 plus a contribution from state-managed fisheries. This rating is conditional on whether past spatial/temporal patterns of prey harvest have played a role in the past population decline of harbor seals and whether future combined harvest patterns actually cause localized depletions of food to the point that population-level effects occur.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on the harbor seal are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on harbor seal are the same as described under FMP 2.1.

- **Cumulative Effects.** Disturbance to harbor seal is found to be cumulative based on contributions from both internal and external effects. This effect was considered insignificant because it is similar to the baseline condition and population-level effects are unlikely.

4.6.8.5 Other Pinnipeds

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

Due to the low level of documented interactions between other pinnipeds and groundfish fisheries (see section 4.5.8.5), takes and entanglements of other pinnipeds incidental to groundfish fisheries under FMP 2.1 are expected to be insignificant according to the criteria established in Table 4.1-6.

Fisheries Harvest of Prey Species

As stated under FMP 1, the effects of fisheries harvests on ice seal prey species are insignificant under the baseline due to limited overlap with the fisheries, and are not likely to change under any of the alternative regimes. The effects of fisheries harvest on prey species are determined to be insignificant to ice seals under FMP 2.1.

With regard to Pacific walrus, their diet is composed almost exclusively of benthic invertebrates (97 percent), particularly bivalve molluscs. Fish ingestion has been considered incidental to their normal feeding behavior (Fay and Stoker 1982). Groundfish removals would not have a significant effect on walrus populations.

The diet of northern elephant seals in the GOA is unknown; however, the species is known to be a deep diver. This behavior suggests that their foraging may be partitioned by depth from most groundfish fishing activities. The effects of groundfish harvests on prey species for northern elephant seals are determined to be unknown under all of the alternative FMPs.

Spatial/Temporal Concentration of the Fishery

Due to the limited potential for competitive overlap between pinnipeds included in this section and the groundfish fisheries, the spatial/temporal concentrations of the fisheries are expected to be insignificant to marine mammals in this category under all of the alternative FMP scenarios.

Disturbance

FMP 2.1 repeals area closures established for the protection of some of the species in the "other pinnipeds" category (e.g. walrus). The level of disturbance on pinnipeds is expected to increase under the 2.1 management regime. Coupled with the expansion of the fishery into new areas and an overall increase in fishing pressure, disturbance of animals under FMP 2.1 may increase to a level at which population level effects could occur, especially on walrus as groundfish fisheries would be permitted in the immediate vicinity

of important walrus habitat. The effect of disturbance is therefore rated conditionally significantly adverse for "other pinnipeds."

Cumulative Effects

The past/present effects on "other pinnipeds" are described in Section 3.8.3 and Sections 3.8.5 through 3.8.9 (Tables 3.8-3 and 3.8-5 through 3.8-9) and the predicted direct/indirect effects of the groundfish fishery under FMP 2.1are described above. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Incidental take and entanglement under FMP 2.1 for species in the "other pinniped" category are considered insignificant.

- **Persistent Past Effects.** Past external effects on the populations of pinniped include low levels of incidental take in the foreign, JV, and domestic groundfish fisheries and low levels of take in the State-managed fisheries. Spotted seal incidental mortality in groundfish fisheries is one per year between 1995 and 1999 (Angliss *et al.* 2001). For bearded seal, the BSAI groundfish fisheries take an average of 0.6 per year. The Bristol Bay salmon drift gillnet fishery from 1990-1993 indicated that 14 mortalities and 31 injuries of bearded seal. No mortalities of ringed seal have been observed in the last ten years in the BSAI groundfish (Angliss *et al.* 2001). For ribbon seal incidental take, the Bering Sea trawl fishery took one in 1990, one in 1991, and one in 1997. An average of 86 elephant seals is taken each year in various gillnet fisheries from California to Washington. Incidental take included one in the Bering Sea trawl fishery reported in 1990, two in the GOA trawl fishery in 1990, and three in the GOA longline fishery in 1990. One juvenile elephant seal, originally misidentified as a bearded seal, was taken in the Bering Sea trawl fishery in 1991 (Angliss *et al.* 2001). Of the 17 Pacific walrus that were caught each year in groundfish trawl fisheries in the EBS between 1990 and 1997, over 80 percent were already decomposed (Gorbics *et al.* 1998). Subsistence is the major human-cause external factor for morality. Subsistence annual harvest rates include 5,265 spotted seal, 6,788 bearded seal, 100 ribbon seal, 9,567 ringed seal, 1,000 walrus and zero elephant seal.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries will likely continue to take very small numbers of seals in this group. Subsistence take of these marine mammals will likely continue at a similar rate to the baseline conditions.

- **Cumulative Effects.** Mortality within the other pinniped group was considered cumulative, based on both internal effects of the groundfish fisheries and external effects such as subsistence harvest. For spotted, ringed, bearded, and ribbon seals, PBRs cannot be calculated. Walrus take is below PBR and population level effects are unlikely. Elephant seal populations are expanding so overall mortality is considered insignificant. Contributions of the groundfish fisheries to overall mortality is very small.

Abundance of Prey

- **Direct/Indirect Effect.** Except for elephant seals, where the amount of prey overlap is unknown, there is very little overlap of species taken in the groundfish fisheries with prey of the pinnipeds in this group and the effects of fisheries harvest on prey species are determined to be insignificant under FMP 2.1.

- **Persistent Past Effects.** Past effects on spotted seal prey include foreign, JV, and domestic groundfish fisheries and State-managed fisheries for salmon and herring. For the ice seals, elephant seals and walrus, no persistent past effects were identified due to minimal overlap with commercial fisheries.

- **Reasonably Foreseeable Future External Effects.** Future effects on the spotted seal were identified from state-managed fisheries. Climate change may be either a beneficial factor or adverse factor for the ice seals, due to the potential effects on the extent of ice cover in the Bering Sea and effect on abundance and distribution of prey.

- **Cumulative Effects.** The cumulative effect of all fisheries on the abundance of prey for pinnipeds is considered insignificant for all species. Spotted seals have some overlap of prey with the groundfish fisheries but the harvest of prey by the fisheries is not expected to have population level effects. The amount of groundfish fishery overlap with elephant seals is unknown but, since the elephant seal population is expanding, food does not appear to be limiting so cumulative effects on prey availability are considered insignificant. The amount of prey overlap with the other pinniped species is very limited and is considered insignificant for all species in this group.

Spatial/Temporal Concentration of Fisheries

- **Direct/Indirect Effects**. The spatial/temporal concentrations of the fisheries are expected to be inconsequential to animals in this category under all of the alternative FMP scenarios, and are therefore rated as insignificant.

- **Persistent Past Effects.** Persistent past effects on spotted seal include foreign, JV, and domestic groundfish fisheries and State-fisheries. For Other Species, no persistent past effects are identified.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries within the range of spotted seal would be expected to be conducted in the future in a manner similar to the baseline conditions. Future effects of spatial/temporal concentration of fisheries on ice seals and walrus would not be expected.

- **Cumulative Effects.** The spatial/temporal concentration of the groundfish fishery and all other fisheries is considered to have an insignificant cumulative effect on pinniped prey due to limited overlap. Population-level effects are unlikely for any of the species in this group.

Disturbance

- **Direct/Indirect Effects.** Increased levels of disturbance from the baseline are expected under the FMP 2.1 and are considered conditionally significant adverse.

- **Persistent Past Effects.** Past sources of disturbance of spotted seals have come from the foreign, JV, and the federal domestic groundfish fisheries in the BSAI and state-managed fisheries for salmon. Overlap of fisheries is minimal for most of species. The primary source of external disturbance to the "other pinniped" category would be related to the subsistence harvest.

- **Reasonably Foreseeable Future.** State-managed fisheries could be expected to continue at a level similar to the baseline conditions. Disturbance from subsistence harvest activities in future years would be expected to be similar to the baseline conditions.

- **Cumulative Effects.** Disturbance was determined to be cumulative based on both internal and external effects. This cumulative effect is found to be conditionally significant adverse, especially for walrus, based on repeal of groundfish area closures and greatly increased fishing activity. This rating is conditional on the location and timing of the expanded fisheries actually causing population-level effects on the different species.

Direct/Indirect Effects FMP 2.2

Incidental Take/Entanglement in Marine Debris

Due to the low level of documented interactions between other pinnipeds and groundfish fisheries, incidental takes and entanglements of other pinnipeds under FMP 2.2 are likely to be similar to the baseline condition and are determined to be insignificant according to the criteria established in Table 4.1-6.

Fisheries Harvest of Prey Species

Effects do not deviate from those described under 2.1 and are considered insignificant.

Spatial/Temporal Concentration of the Fishery

Effects do not deviate from those described under 2.1 and are considered insignificant.

Disturbance

Disturbance of pinnipeds under FMP 2.2 is not expected to increase relative to the baseline and is therefore considered to be insignificant.

Cumulative Effects

The past/present effects on the other pinnipeds are described in Section 3.8.3 and Sections 3.8.5 through 3.8.9 (Tables 3.8-3 and 3.8-5 through 3.8-9). Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Effects of incidental take and entanglement under FMP 2.2 are considered insignificant.

- **Persistent Past Effects.** Persistent past effects on other pinnipeds are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on other pinnipeds are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effect of mortality on other pinnipeds is the same as described under FMP 2.1 and is considered insignificant.

Prey Availability

- **Direct/Indirect Effects.** Effects on prey availability under FMP 2.2 are considered insignificant.

- **Persistent Past Effects.** Persistent past effects on other pinnipeds are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on other pinnipeds are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effect of prey availability on other pinnipeds is the same as described under FMP 2.1 and is considered insignificant.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effects.** Effects of spatial/temporal concentration of the fisheries under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on other pinnipeds are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on other pinnipeds are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effect of spatial/temporal concentration of harvest is the same as described under FMP 2.1 and is considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on other pinnipeds are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on other pinnipeds are the same as described under FMP 2.1

- **Cumulative Effects.** Cumulative effects of disturbance on other pinnipeds are likely to be similar to the baseline condition and are therefore considered insignificant and unlikely to have population effects on any species considered.

4.6.8.6 Transient Killer Whales

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

Increased harvest rates under this management alternative may result in the increased take of fewer than one killer whale relative to the baseline (see section 4.5.8.6), for a total estimated average of fewer than 3 animals per year. Most incidental takes in the fisheries are probably resident killer whales since they feed on fish and would be more likely to be drawn to fishing vessels. This level of incidental take would not result in changes to the population trajectory of transient killer whales. Therefore, takes and entanglements of transient killer whales incidental to groundfish fisheries under FMP 2.1 are determined to be insignificant according to the criteria established in Table 4.1-6.

Fisheries Harvest of Prey Species

The diet of transient killer whales consists of marine mammals. Since the groundfish fisheries are expected to kill very few marine mammals through incidental take under FMP 2.1, the direct effects of groundfish fisheries on the abundance of transient killer whale prey species are determined to be insignificant under FMP 2.1.

Spatial/Temporal Concentration of the Fishery

The spatial/temporal concentration of the groundfish fisheries does not directly affect the distribution of marine mammals. Therefore, the direct effects of the fisheries on transient killer whale prey are determined to be insignificant under FMP 2.1.

Disturbance

FMP 2.1 would result in the repeal of area closures established for the protection of environmental components other than Steller sea lions, such as the Pribilof Islands habitat conservation area, the walrus protection area, salmon, herring, and crab savings areas, and certain areas that were closed to trawling under the baseline. Coupled with the expansion of the fishery into new areas and an overall increase in fishing pressure, disturbance of marine mammals under FMP 2.1 may increase to the level that population level effects could occur and is, therefore, determined to be conditionally significant adverse to transient killer whales.

Cumulative Effects

The past/present effects on the transient killer whales are described in Section 3.8.22 (Table 3.8-22) and the predicted direct/indirect effects of the groundfish fishery under FMP 2.1 are described above. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effect.** With regard to incidental take, FMP 2.1 is likely to have insignificant effects on the population trajectory of transient killer whales.

- **Persistent Past Effects.** Mortality has been documented in the JV fisheries, domestic groundfish fisheries, state-managed fisheries, and intentional shootings. Past incidental take in the groundfish fisheries is fewer than two animals per year but it is not known if these animals were transients or residents. In addition to mortalities caused by entanglement, killer whales are also susceptible to injury or mortality through vessel strikes. One killer whale was reported to be killed when it struck the propeller of a BSAI groundfish trawl vessel in 1998 (Angliss and Lodge 2002). The EVOS resulted in the loss of half of the individual killer whales from the AT1 pod in PWS (Matkin *et al.* 1999). This distinct group of whales is being evaluated for recognition as a separate stock and for protection as a depleted stock under the MMPA. Contaminant levels in whales in this group were found to be many times higher than in other killer whales (Makin *et al.* 1999).

- **Reasonably Foreseeable Future External Effects.** Mortality from external factors is identified for other state-managed fisheries, intentional shooting, and marine pollution, particularly bio-accumulating pollutants such as DDT and PCBs (Matkin *et al.* 1999).

- **Cumulative Effects.** Mortality is considered cumulative based on the internal effects of the groundfish fisheries and external effects of other fisheries. The cumulative effects are determined to be insignificant and are unlikely to have population level effects. The exception to this finding is the AT1 transient group in PWS. The cumulative effect of mortality on this group was determined to be significantly adverse due to the past external effects of the EVOS and subsequent population decline.

Prey Availability

- **Direct/Indirect Effects.** Since the groundfish fisheries kill very few marine mammals through incidental take, the direct effects of groundfish fisheries on the abundance of transient killer whale prey species are determined to be insignificant.

- **Persistent Past Effects.** Since marine mammals are the primary prey of transient killer whales, all of the factors that have been identified as affecting the abundance or distribution of cetaceans, pinnipeds, and sea otters are pertinent in this context. These factors include commercial and subsistence harvest, intentional shootings, incidental take in all fisheries, marine pollution, climate change, and regime shifts. In addition, there is the potential for past indirect effects of fisheries on the abundance of Steller sea lions, fur seals, and harbor seals, all of which are important prey species for transient killer whales. Declines in harbor seals in PWS after the EVOS could have affected the AT1 group of transient killer whales through their food supply (Matkin *et al.* 1999).

- **Reasonably Foreseeable Future External Effects.** Future external effects on prey species important to transient killer whales, primarily marine mammals, would include state-managed fisheries to a smaller extent and subsistence harvest of the various marine mammals.

- **Cumulative Effects.** The cumulative effects on different marine mammal species are varied, with some populations declining substantially while others increase. Although some individual whales may specialize on particular prey species, the ability of these top predators to switch prey and forage over vast areas is believed to decrease the importance of any one species or stock of marine mammal prey. The overall availability of prey does not appear to be having population level effects on transient killer whales and therefore the cumulative effect is considered insignificant.

Spatial/Temporal Concentration of the Fishery

- **Direct/Indirect Effects.** The spatial/temporal concentration of the groundfish fisheries does not directly affect the distribution of marine mammals. Therefore, the direct effects of the fisheries on transient killer whale prey are determined to be insignificant.

- **Persistent Past Effects.** All persistent past effects that have been identified for cetaceans, pinnipeds, and sea otters are pertinent in this context. These factors include the potential contribution of the spatial/temporal concentration of past fisheries to have caused localized depletion of prey for Steller sea lions, harbor seals, and northern fur seals with consequent population-level effects on those species.

- **Reasonably Foreseeable Future External Effects.** The future spatial/temporal concentration of external fisheries could have indirect effects on the abundance and distribution of marine mammals that are important prey for transient killer whales.

- **Cumulative Effects.** The cumulative effects of the spatial/temporal concentration of fisheries on different marine mammal species result in changes to the abundance and distribution of prey to transient killer whales. Since transient killer whales. are able to switch prey and forage over vast areas, the potential localized depletion of any one species or stock of marine mammal prey is unlikely to have population level effects on the killer whales. The cumulative effect of the spatial and temporal harvest of fish from all fisheries does not appear to be having population level effects on transient killer whales and is therefore considered insignificant.

Disturbance

- **Direct/Indirect Effects.** Levels of disturbance to killer whales are expected to increase substantially from the baseline and are rated conditionally significant adverse.

- **Persistent Past Effects.** Some levels of disturbance have likely come from foreign, JV, and domestic groundfish fisheries, and state-managed fisheries. Vessel traffic external to the fisheries has also contributed to overall disturbance of these animals. Effects of the level of disturbance on transient killer whales are largely unknown.

- **Reasonably Foreseeable Future External Effects.** External effects of State-managed fisheries and other vessel traffic on disturbance will likely occur in future years at a level similar to the baseline.

- **Cumulative Effects.** Disturbance of transient killer whales was determined to be cumulative based on the presence of both internal and external factors. This cumulative effect is considered conditionally significant adverse and likely to have population level effects. This is conditional on

the actual location and timing of the disturbance and whether transient killer whales are displaced from areas important to the species to the extent that population level effects occur.

Direct/Indirect Effects FMP 2.2

For transient killer whales, the analysis and conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 2.2 are the same as discussed under FMP 2.1 and are considered insignificant on the population level.

Disturbance

Disturbance of killer whales under the FMP 2.2 management regime is not expected to increase relative to the baseline and is therefore rated insignificant.

Cumulative Effects

For transient killer whales, the analysis and conclusions regarding cumulative effects for mortality, prey availability, and spatial and temporal concentration of the fishery under FMP 2.2 are the same as discussed under FMP 2.1 and are considered insignificant on the population level.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance under FMP 2.2 are determined to be insignificant.
- **Persistent Past Effects.** Persistent past effects on the transient killer whales are the same as described under FMP 2.1.
- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on transient killer whales are the same as described under FMP 2.1.
- **Cumulative Effects.** Disturbance of transient killer whales was determined to be cumulative based on the presence of both internal and external factors. This cumulative effect is expected to be generally similar to the baseline condition, is not likely to have population-level effects, and is therefore considered insignificant.

4.6.8.7 Other Toothed Whales

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

With regard to incidental take, FMP 2.1 is not likely to result in significant changes to the population trajectories of toothed whales, including the endangered sperm whale. Incidental takes attributed to the fisheries and entanglement in fishing gear and marine debris occur at low levels thought to be insignificant to toothed whale populations (see Section 4.5.8.7).

Fisheries Harvest of Prey Species

The effects of the alternatives on the toothed whales are largely constrained by differences between their prey and the fisheries harvest targets. FMP 2.1 is not expected to increase the level of interactions relative to the baseline and are determined to be insignificant at the population level.

Spatial/Temporal Concentration of the Fishery

Groundfish fisheries have little competitive overlap with toothed whales. Spatial and temporal fishing measures under the baseline conditions do not appear to be causing localized depletion of prey for any species of toothed whale. Changes to the spatial/temporal concentration of the fisheries under FMP 2.1 are expected to result in effects that are insignificant to toothed whales at the population level.

Disturbance

FMP 2.1 repeals area closures established for the protection of environmental components other than Steller sea lions such as the Pribilof Islands habitat conservation area, the walrus protection area, salmon, herring, and crab savings areas, and certain areas that were closed to trawling under the baseline. Coupled with the expansion of the fishery into new areas and an overall increase in fishing pressure, disturbance of animals under FMP 2.1 may increase to the level that population level effects could occur and is therefore determined to be conditionally significant adverse to endangered sperm whales and other toothed whales.

Cumulative Effects

The past/present effects on the other toothed whale category are described in Section 3.8.19 through 3.8.21 and 3.8.23 through 3.8.25 (Tables 3.8-19 through 3.8-25) and the predicted direct/indirect effects of the groundfish fishery under FMP 2.1 are described above. The effects considered in this analysis are listed in Table 4.6-5. Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** Incidental takes attributed to the fisheries and entanglement in fishing gear and marine debris occur at low levels thought to be insignificant at the population level for all species in the toothed whale category and are therefore insignificant.

- **Persistent Past Effects.** Persistent past effects on species within the other toothed whale group include incidental take and entanglement in foreign, JV, federal domestic groundfish fisheries and state-managed fisheries and subsistence hunting on beluga whales. The decline of the Cook Inlet beluga population is thought to have resulted from subsistence harvests, which ranged from 21 to 123 animals per year between 1993 and 1998. Only one beluga was harvested in 2001 by hunters from Native Village of Tyonek and one beluga in 2002 by the Cook Inlet community hunters. Belugas are incidentally taken in the state-managed salmon gillnet fisheries in Bristol Bay and Cook Inlet. However, one beluga was reported to be taken from the eastern Bering Sea stock in 1996 and 7 were reported taken in Bristol Bay in 2000. In the BSAI and GOA groundfish fisheries, no mortality or serious injuries to belugas have been observed. Harbor porpoise have not been taken in the observed groundfish fisheries over a ten-year period between 1990 to 1998 (Angliss and Lodge

2002). Salmon gillnet fisheries in southeast Alaska take approximately 3 individuals per year. Dall porpoise mean annual mortality was 6.0 for the Bering Sea groundfish trawl fishery, 1.2 for the GOA groundfish trawl fishery, and 1.6 for the Bering Sea groundfish longline fishery. The Alaska Peninsula/Aleutian Island salmon drift gillnet fishery has a higher take of Dall's Porpoise with an estimated 28 porpoises in one year (1990). Thousands of Pacific white-sided dolphins were killed annually between 1978 and 1991 in the high seas driftnet fisheries, which no long occur (Angliss *et al.* 2001). During the same time span, one Pacific white-sided dolphin was taken in the BSAI trawl fishery and one in the BSAI longline fishery (Angliss *et al.* 2001). State-managed salmon gillnet fisheries take approximately 2 dolphins per year.

Approximately 258,000 sperm whales in the North Pacific were harvested by commercial whalers between 1947 and 1987 with high counts occurring in 1968 when 16,357 sperm whales were harvested, after which the population was severely depleted. Sperm whale interactions with longline fisheries operating in the GOA are known to occur and may be increasing in frequency. Sperm whales have been known to prey on sablefish caught on commercial longline gear in the GOA. Only three entanglements have been reported in the GOA longline fishery.

For killer whales, the combined mortality from the observed groundfish fisheries was 1.4 whales per year (Angliss *et al.* 2001). While it is most likely that whales interacting with fisheries are from resident pods (since they eat fish), no genetic testing has been done on whales incidentally taken in the groundfish fisheries to ascertain whether they were from resident or transient stocks.

For beaked whales (Baird's, Cuvier's, or Stejneger's), no incidental take or entanglement in BSAI and GOA groundfish trawl, longline, and pot fisheries has been documented (Hill and DeMaster 1999).

- **Reasonably Foreseeable Future External Effects.** Future effects on mortality of these species were identified for state-managed fisheries and subsistence for some species such as the beluga whale. Total mortality from these sources is expected to be very minimal.

- **Cumulative Effects.** Cumulative effects of mortality were determined to be insignificant for all non-ESA-listed species based on the internal contribution from the groundfish fisheries and external contribution from other sources. This cumulative effect rating is due to the low level of incidental take in the groundfish fisheries and limited external human-caused mortality.

For the endangered sperm whale, the cumulative effect of mortality was also considered insignificant due to the very low level of incidental take from the groundfish fisheries and other fisheries and very limited human-caused mortality from external sources.

Prey Availability

- **Direct/Indirect Effects.** The effects of FMP 2.1 on the toothed whales are largely constrained by differences between their prey and the fisheries harvest targets and are determined to be insignificant at the population level.

- **Persistent Past Effects.** Past effects on the availability of prey for this group are identified for fisheries in general and include the foreign, JV, and federal domestic groundfish fisheries and the

state-managed fisheries for salmon and herring. The diversity of diet in this whale group results in limited overlap for most species with the possible exception of sperm whales and resident killer whales.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries were identified as an external factor having a potential effect on prey for these species in the future. Climate and regime shift are also identified but the direction and magnitude of these effects could be either beneficial or adverse.

- **Cumulative Effects.** The ability of these whale species to forage over wide areas and on a variety of prey species moderates any potential impacts from fisheries competition. Cumulative effects on prey availability were identified for this group, including a very limited contribution from the groundfish fishery, but the degree of fishery harvest and bycatch of prey important to these whale species is not expected to have population-level effects on any species, including the endangered sperm whale, and is therefore considered insignificant.

Spatial/Temporal Concentrations of the Fisheries

- **Direct/Indirect Effect.** The groundfish fisheries have little competitive overlap with toothed whales so changes to the spatial/temporal concentration of the fisheries under FMP 2.1 are expected to result in effects that are insignificant to toothed whales at the population level.

- **Persistent Past Effects.** The spatial/temporal concentration of foreign, JV, and domestic groundfish fisheries and the State-managed fisheries are believed to have had minimal effects on the abundance and distribution of toothed whale prey.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries are expected to continue in similar manner as the under the baseline conditions. Effects of future external activities on toothed whale prey are expected to be minimal.

- **Cumulative Effects.** The ability of toothed whales to forage over wide areas and on a variety of prey species moderates any potential impacts from localized depletion of prey from the spatial/temporal concentration of fisheries. Cumulative effects on prey abundance and distribution, including a very limited contribution from the groundfish fishery, are not expected to have population-level effects on any species, including the endangered sperm whale, and are therefore considered insignificant.

Disturbance

- **Direct/Indirect Effect .** Increased levels of disturbance from the baseline are expected under the FMP 2.1 and are considered conditionally significant adverse.

- **Persistent Past Effects.** Past potential disturbance effects on species in this group were identified for foreign, JV, and federal domestic groundfish fisheries; however, there is little indication of an adverse effect of this level of disturbance. General vessel traffic likely also contributes to disturbance to these species.

- **Reasonably Foreseeable Future External Effects.** Increases in the general marine vessel traffic and continued fishing activity in the state-managed fisheries were identified as potential sources of disturbance for these species.

- **Cumulative Effects.** Disturbance was determined to be cumulative based on both internal and external effects. This cumulative effect is considered conditionally significant adverse and likely to have population level effects for endangered sperm whale and other toothed whales. This rating is conditional on the actual location and timing of the disturbance and whether toothed whales are displaced from important foraging areas to the extent that population level effects occur.

Direct/Indirect Effects FMP 2.2

For toothed whales in this group, the analysis and conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 2.2 are the same as discussed under FMP 2.1 and are considered insignificant on the population level.

Disturbance

Disturbance of toothed whales under the FMP 2.2 management regime is not expected to increase relative to the baseline and is therefore considered to be insignificant.

Cumulative Effects

For toothed whales in this group, the analysis and conclusions regarding cumulative effects for mortality, prey availability, and spatial and temporal concentration of the fishery under FMP 2.2 are the same as discussed under FMP 2.1 and are considered insignificant on the population level.

Disturbance

- **Direct/Indirect Effects.** Effects of disturbance under FMP 2.2 are determined to be insignificant.

- **Persistent Past Effects.** Persistent past effects on endangered sperm whales and non ESA-listed toothed whales are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects on endangered sperm whales and non ESA-listed toothed whales are the same as described under FMP 2.1.

- **Cumulative Effects.** Disturbance from both internal and external effect on endangered sperm whales and non ESA-listed toothed whales is likely to be similar to the baseline level and is considered insignificant at the population level for all species.

4.6.8.8 Baleen Whales

FMP 2.1 – Direct/Indirect Effects

Incidental Take/Entanglement in Marine Debris

With respect to take and entanglement in marine debris incidental to groundfish fisheries, FMP 2.1 does not conflict with any recovery plan for endangered whales, and is expected to have an insignificant effects on the population trajectories of baleen whales. See the discussion provided for incidental take of other baleen whales in Section 4.5.8.8.

Fisheries Harvest of Prey Species

The effects of FMP 2.1 are determined to be insignificant to baleen whale species in regards to harvest of prey due to the lack of competitive overlap in species targeted by each.

Spatial/Temporal Concentration of the Fishery

Groundfish fisheries have very little competitive overlap with baleen whales for forage species, therefore, changes to the spatial/temporal concentration of the fisheries under FMP 2.1 are expected to result in effects that are insignificant to baleen whales at the population level.

Disturbance

FMP 2.1 repeals area closures established for the protection of environmental components other than Steller sea lions such as the Pribilof Islands habitat conservation area, the walrus protection area, salmon, herring, and crab savings areas, and certain areas that were closed to trawling under the baseline. Coupled with the expansion of the fishery into new areas and an overall increase in fishing pressure, disturbance of animals under FMP 2.1 may increase to the level that population-level effects could occur and is therefore determined to be conditionally significantly adverse to endangered baleen whale species and other non ESA-listed baleen whales.

Cumulative Effects

The past/present effects on the other baleen whale group are described in Sections 3.8.11 through 3.8.18 (Tables 3.8-11 through 3.8-18) and the predicted direct/indirect effects of the groundfish fishery under the FMP 2.1 bookend are described above (Table 4.6-5). Representative direct effects used in this analysis include mortality and disturbance with the major indirect effects of availability of prey and spatial/temporal concentration of the fisheries (Table 4.6-1).

Mortality

- **Direct/Indirect Effects.** The low level of take of baleen whales projected to occur under FMP 2.1 is considered insignificant.

- **Persistent Past Effects.** Commercial whaling during the last century has had a lingering effect on almost all of the baleen whales in this group, with the possible exception of the minke whale. These

include the endangered blue whales, fin whales, sei whales, humpback whales, northern right whales and the non ESA listed gray whales. A full discussion of the effects of commercial whaling is presented in Section 3.8.9. Subsistence whaling has also affected several of the baleen whales in the past. Gray whales are harvested both in Alaska and in Russia with a 5-year quota of 620 whales. The 1968-1993 average take for Russian and Alaska Natives combined was 159 whales per year. Bowhead whales are harvested under International Whaling Commission which allows up to 67 strikes per year although actual strikes have been fewer than the quota since 1978. A single fin whale mortality was reported in the GOA pollock trawl fishery operating south of Kodiak Island and Shelikof Strait in autumn 1999. Fin whales were reported in this region year-round, most often in the summer and autumn (POP 1997). Humpback whales are present year-round in Alaska waters but are most frequently reported during the summer and autumn. In 1997, a dead humpback was found entangled in netting and trailing orange buoys near the Bering Strait. It is often difficult to determine if the entanglement occurred with active or derelict gear, or to identify the fishery the derelict gear originated from. Two mortalities (in October 1998 and February 1999) were reported by observers in the BS pollock trawl fishery operating near Unimak Pass. The extent of interactions between bowhead whales and the groundfish fishery are not known. Bowhead whales are present in the Bering Sea during winter and early spring but are usually associated with ice-covered regions. Rope entanglement injuries and deaths as well as ship-strike injuries appear to be rare. Of 236 bowhead whales examined from the Alaskan subsistence harvest (from 1976 to 1992), three had visible ship-strike injuries from unknown sources and six had ropes attached or scars from fishing gear (primarily pot gear), one found dead was entangled in ropes similar to those used with fishing gear in the Bering Sea (Philo *et al.* 1992). Since 1992, additional bowhead whales have been observed entangled in pot gear or with scars from ropes. The extent of interactions between gray whales and the groundfish fishery is not known. Rope entanglement injuries and deaths as well as ship-strike injuries appear to be rare. Since 1997, five entanglements (mostly in pot gear) and one ship strike mortality have been reported in Alaska waters. Since 1989, no incidental takes of right whales are known to have occurred in the north Pacific. Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula (Russia) in October of 1989. Because the right whale population is believed to be very small, any mortality incidental to commercial fisheries would be considered to be significant. Yet, based on the lack of reported mortalities of right whales, the estimated annual mortality rate incidental to commercial fisheries is zero whales per year from this stock.

- **Reasonably Foreseeable Future External Effects.** Foreign fisheries outside the EEZ and State-managed fisheries are expected to continue to take small numbers of baleen whales in the coming years. Entanglement in fishing gear will also continue to affect baleen whales throughout their ranges. Subsistence for gray whales and bowhead will continue to be the largest source of human-caused mortality.

- **Cumulative Effects.** Cumulative effects of mortality resulting from internal effects of the fishery and contributions from external factors are considered conditionally significant adverse for fin, humpback, and northern right whales due to past effects on their population, potential for interactions with fisheries, and their endangered status. Right whales are very rare so even one human-caused mortality could be considered significant. Given the overlap of their preferred habitat with the BSAI fisheries, the chances of future adverse interactions with fishing gear are more than negligible. The adverse rating for these three species is conditional on whether future take or entanglement substantially affects their rates of recovery. Cumulative effects are found to be insignificant for the endangered blue, bowhead, and sei whales. These species rarely interact with

the fisheries so population-level effects are not anticipated. Mortality is also considered insignificant for non-ESA-listed minke and gray whales. Population-level effects are not expected for either of these species.

Prey Availability

- **Direct/Indirect Effects.** The effects of FMP 2.1 are determined to have an insignificant effect on both endangered and non ESA-listed baleen whale species due the lack of competitive overlap in species targeted.

- **Persistent Past Effects.** Persistent past effects on availability of prey were not identified due to the lack of competitive overlap in prey species targeted.

- **Reasonably Foreseeable Future External Effects.** Future effects were identified for state-managed fisheries such as herring, which are preyed on by humpback whales and fin whales. Other species would not be affected through prey.

- **Cumulative Effects.** The cumulative effects of prey availability are considered insignificant for both endangered and non ESA-listed whale species in this group due to the limited overlap of prey species with the fisheries. Population-level effects are not anticipated.

Temporal and Spatial Concentration of the Fishery

- **Direct/Indirect Effect.** Changes to the spatial/temporal concentration of the fisheries are expected to result in insignificant effects for both endangered and non ESA-listed baleen whales at the population-level.

- **Persistent Past Effects.** Persistent past effects of temporal and spatial concentrations of the fisheries were not identified.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries would continue to contribute some degree of effect on several species of baleen whales.

- **Cumulative Effects.** Cumulative effects on prey availability are not likely to have population-level effects due to the very low overlap in prey species for this group and are considered insignificant. The contribution of the groundfish fisheries is minimal.

Disturbance

- **Direct/Indirect Effects.** Increased levels of disturbance in comparison to the baseline would likely occur to both endangered and non ESA-listed baleen whales under the FMP 2.1and are considered conditionally significant adverse.

- **Persistent Past Effects.** Some level of disturbance has likely occurred from foreign, JV, and domestic groundfish fishing and state -managed fisheries along with general vessel traffic. For some species such as the gray whale and bowhead whale, subsistence activities have contributed to disturbance of these animals.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries and general vessel traffic from recreational boating and whale watching to commercial fishing would be expected to continue in future years and well as subsistence activities.

- **Cumulative Effects.** The cumulative effects of disturbance were determined to likely result in population-level effects for both endangered and non ESA-listed species in this group and, therefore, are considered conditionally significant adverse. This rating is conditional on the actual location and timing of the disturbance and whether baleen whales are displaced from important foraging areas to the extent that population level effects occur.

Direct/Indirect Effects FMP 2.2

For baleen whales, the analysis and conclusions regarding direct/indirect effects for incidental take and entanglement in marine debris, fisheries harvest of prey species, and spatial and temporal concentration of the fishery under FMP 2.2 are the same as discussed under FMP 2.1 and are considered insignificant on the population level.

Disturbance

Disturbance of both endangered and non ESA-listed baleen whales under the FMP 2.2 management regime is not expected to increase relative to the baseline and is therefore considered insignificant.

Cumulative Effects

For baleen whales, the analysis and conclusions regarding cumulative effects for mortality, prey availability, and spatial and temporal concentration of the fishery under FMP 2.2 are the same as discussed under FMP 2.1 and are considered insignificant on the population level.

Disturbance

- **Direct/Indirect Effect.** Similar levels of disturbance as those that occurred to both endangered and non ESA-listed baleen whales under baseline conditions are expected under FMP 2.2 and are considered insignificant.

- **Persistent Past Effects.** Persistent past effects of disturbance are the same as described under FMP 2.1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects of disturbance on baleen whales are the same as described under FMP 2.1.

- **Cumulative Effects.** The cumulative effect of disturbance from both internal and external sources is determined to be similar to the baseline condition and not likely to result in a population-level effect for any of the species in this group. Therefore, the cumulative effect is considered to be insignificant.

4.6.8.9 Sea Otters

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Incidental Take/Entanglement in Marine Debris

With respect to take and entanglement in marine debris incidental to groundfish fisheries, FMP 2.1 and FMP 2.2 are not expected to result in significant effects on the population trajectories of sea otters. See the discussion provided for incidental take of sea otters in Section 4.5.8.9.

Fisheries Harvest of Prey Species

Given the minor importance of groundfish in their diet (see Section 4.5.8.9), fisheries removals under FMP 2.1 and FMP 2.2 are not expected to substantially alter sea otter prey abundance relative to the baseline and are considered to have insignificant effects on sea otters.

Spatial/Temporal Concentration of the Fishery

The grounds for suggesting competition for forage between sea otters and commercial fisheries is weak despite the broad geographical distribution of sea otters in the GOA and the Aleutian Islands. Sea otters inhabit waters of the open coast, as well as bays and the inside passages of southeastern Alaska. Since their primary prey items are found on the bottom in the littoral zone, to depths of 50 m, the majority of otters feed within 1 km of the shore (Kenyon 1969). In areas where shallow waters extend far offshore (e.g., Unimak Island), sea otters have been reported as far as 16 km offshore. They are often seen resting and diving for food in and near kelp beds (Kenyon 1969). Because of this habitat preference for shallow areas, they do not overlap spatially with groundfish fisheries. Therefore, the effects of the spatial/temporal concentrations of the fisheries are insignificant for sea otters for both FMP 2.1 and FMP 2.2

Disturbance

FMP 2.1 repeals area closures established for the protection of environmental components other than Steller sea lions, such as the Pribilof Islands habitat conservation area, the walrus protection area, salmon, herring, and crab savings areas, and certain areas that were closed to trawling under the baseline. The level of disturbance on sea otters is not expected to increase under FMP 2.1 due to the spatial partitioning of sea otters, which occur in shallow, nearshore areas, and groundfish fisheries. The disturbance levels predicted under FMP 2.2 are not expected to deviate from baseline conditions. Therefore, the effects of disturbance from groundfish fisheries on sea otters are rated insignificant according to the criteria in Table 4.1-6.

Cumulative Effects

The past/present effects on the sea otter are described in Section 3.8.10 (Table 3.8-10) and the predicted direct/indirect effects of the groundfish fishery under FMP 2.1 and FMP 2.2 are described above. The effects considered in this analysis are listed in Table 4.5-70. Representative direct effects used in this analysis include mortality and disturbance with major indirect effects being availability of prey and spatial/temporal concentration of the fisheries (Table 4.1-6).

Mortality

- **Direct/Indirect Effects.** The effects on sea otters under FMP 2.1 and FMP 2.2 are considered insignificant, with respect to incidental catch and entanglement.

- **Persistent Past Effects.** Commercial exploitation for pelts had a huge impact on sea otters dating from the mid-1700s to the late 1800s, causing them to become nearly extinct (Bancroft 1959, Lensink 1962). Protective measures instituted in 1911 have allowed remnant groups to increase and reoccupy much of the historic sea otter range in Alaska (Kenyon 1969, Estes 1980). Residual effects from this early harvest likely persist in several areas. Alaska Natives have hunted sea otters for pelts and meat throughout history. Current harvest levels represent 9 percent of PBR for the southwestern stock, 15 percent of PBR for the southcentral stock, and 35 percent of PBR for southeast stock. (USFWS 2002a, 2002b, and 2002c). In 1992, fisheries observers reported 8 sea otters taken incidentally by the Aleutian Island Black Cod Pot Fishery. During that year, only a third of the fisheries were observed, yielding an estimate of 24 otters killed in cod pot gear. No other sea otter takes were reported from observed fisheries in the range of the southwest stock from 1993 through 2000. In 1997, one sea otter was reported to have been taken by the BSAI groundfish trawl fishery (USFWS 2002a, 2002b, and 2002c). Oils spills, such as the EVOS, can result in substantial mortality of sea otters. Sea otter numbers have declined dramatically from the Alaska Peninsula to the Bering Sea, and this stock is being considered for listing under the ESA.

- **Reasonably Foreseeable Future External Effects.** Low levels of incidental take in commercial and subsistence fisheries, subsistence hunting, and periodic mortalities from oil spills are likely to continue in the future. Population-level effects from transient killer whale predation may continue in the southwest Alaska stock, depending on the recovery of alternate prey and behavior of transient killer whales.

- **Cumulative Effects.** The cumulative effects of mortality from all sources are different for different stocks of sea otters. The populations of the southeast and southcentral stocks of sea otters appear to be stable or increasing and are not expected to have additional mortality pressures in the future. These stocks are therefore considered to experience insignificant effects from mortality. The rapid decline of the southwest Alaska stock does not appear to be the result of food shortages, disease, or toxic contamination and is likely the result of increased predation by transient killer whales following the collapse of their preferred sea lion prey population in the 1980s (Estes *et al.* 1998). Since the mechanisms of the population decline are still under investigation, the cumulative effects on the southwest stock are considered conditionally significant adverse through mortality and are conditional on whether excessive mortality is a primary cause for the recent decline.

Prey Availability

- **Direct/Indirect Effects.** The effects of FMP 2.1 and FMP 2.2 on sea otters are limited by differences between their prey and the fisheries harvest targets. Sea otters consume a wide variety of invertebrate prey species and occasionally groundfish (e.g., sablefish, rock greenling, and Atka mackerel). As such, the effects of harvest of key prey species in groundfish fisheries are determined insignificant for sea otters.

- **Persistent Past Effects.** Groundfish fisheries have had little effect on the availability of prey in the past due to the limited overlap in prey species of the sea otter and the fish targeted by the groundfish fisheries. There is some minor overlap in state-managed crab fisheries with sea otter prey.

- **Reasonably Foreseeable Future External Effects.** State-managed crab fisheries that take crab from shallow waters were identified as external sources for effects on prey availability. The overlap primarily occurs in inshore areas or offshore areas with relatively shallow water.

- **Cumulative Effects.** Cumulative effects of prey availability were determined to be insignificant due to the very limited overlap between fisheries and sea otter forage species and are not likely to have population-level effects on sea otters.

Spatial/Temporal Concentration of the Fisheries

- **Direct/Indirect Effects.** Despite the broad geographical distribution of sea otters in the GOA and the Aleutian Islands, they do not generally overlap spatially with groundfish fisheries. Therefore, the effects of the spatial/temporal concentrations of the fisheries are insignificant for sea otters.

- **Persistent Past Effects.** The limited overlap of groundfish fisheries and other fisheries in the past has resulted in limited interaction with sea otters. Past effects may come from spatial/temporal concentration and have likely occurred in very specific areas associated with state-managed crab fisheries.

- **Reasonably Foreseeable Future External Effects.** State-managed crab fisheries are likely to continue into the future at a level similar to the baseline conditions.

- **Cumulative Effects.** Cumulative effects of spatial/temporal concentration of the fisheries are insignificant due to the limited overlap with sea otter habitat and are unlikely to result in population-level effects.

Disturbance

- **Direct/Indirect Effects.** The effects of disturbance caused by vessel traffic, fishing operations, and sound production on sea otters in the GOA and BSAI are expected to be insignificant. Levels of disturbance under the FMP 2.1 and FMP 2.2 are expected to be similar to the baseline and are considered insignificant to sea otter populations.

- **Persistent Past Effects.** Past effects of disturbance are primarily related to minor disturbance by vessel traffic from fisheries and other vessels associated with subsistence harvest of sea otters.

- **Reasonably Foreseeable Future External Effects.** State-managed fisheries are expected to continue at a level similar to the baseline. Vessel traffic within sea otter habitat in future years would also be expected to be similar to the baseline.

- **Cumulative Effects.** Cumulative effects of disturbance on sea otters are considered insignificant and unlikely to result in any population-level effects. Contribution of the groundfish fishery to the overall cumulative effect is minimal.

4.6.9 Socioeconomic Alternative 2 Analysis

This policy alternative would maximize biological and economic yield from the resource while still preventing overfishing of the groundfish stocks. This section contains both quantitative and qualitative assessments of select economic and social effects of FMP 2.1 and FMP 2.2.

4.6.9.1 Harvesting and Processing Sector Profiles

The model and analytical framework used in the analysis of the effects of FMP 2.1 on the harvesting and processing sectors are described in Section 4.1.7.

As in FMP 1, model projections are based on 2001 prices and product mixes. Actual prices may rise or decline with levels of catch, changes in market conditions, or other factors. Since FMP 2.1 results in large increases in the catches of certain species for both catcher vessels and catcher processors, prices may decrease for some species as a result of the increase in supply. The extent to which prices would decrease depends on demand elasticities. Due to the presence of a large number of substitutes for Alaska groundfish products, the demand for these products is believed to be relatively elastic. In other words, prices for groundfish products are unlikely to be substantially influenced by changes in harvests. Also, ex-vessel prices are determined by negotiations between individual processors on one side and either bargaining associations for catcher vessels or individual fishermen on the other side. Ex-vessel prices may not behave as one might expect in a competitive market. Actual prices will ultimately depend on the relative bargaining power of harvesters and processors.

Moreover, the FMP 2.1 model projections of groundfish retained harvests may be overestimated. The elimination of the observer program in all fisheries except the BSAI pollock fishery will increase the reliance of fishery managers on the data collected through current industry recordkeeping and reporting requirements. A reliance on logbook data will significantly decrease the precision of total catch data available for fishery managers. With less precise data, fishery managers are likely to adopt a conservative approach and close fisheries before actual catches reach the TAC.

Table 4.6-6 summarizes projected impacts of FMP 2.1 on the harvesting and processing sectors. The numbers in the table reflect the 5-year average of outcomes projected for 2003 to 2007. Under FMP 2.1, there would be significant increases in the harvest of groundfish species as a result of a large projected increase in the TAC and the removal of PSC limits. The 5-year mean estimate of groundfish wholesale product value is about $2.2 billion, a 52 percent increase when compared to the baseline.

Under FMP 2.1, groundfish wholesale product value is projected to be at a peak of $2.8 billion in 2003. However, the harvest of pollock in the BSAI in that year is predicted to be unsustainable. Consequently, product value is expected to decline rapidly such that product value in 2006 is approximately 68 percent of the 2003 estimated value and 86 percent of the 5-year mean. An upward trend is expected after 2006, and by 2007, the product value is anticipated to be about $1.9 billion.

The 5-year mean estimate of the pollock harvest is 680 thousand mt (47 percent) higher than the comparative baseline. Pacific cod harvest are expected to increase by 165 thousand mt (75 percent), and harvest of flatfish are predicted to increase by 103 thousand mt (60 percent). Species in the A-R-S-O aggregation as a whole are predicted to increase by 40 thousand mt (27 percent). Total groundfish payments to labor are expected to increase by 54 percent, and groundfish employment will increase by about 6,900 FTE positions.

4.6.9.1.1 Catcher Vessels

Direct/Indirect Effects of FMP 2.1

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period in Table 4.6-6 to 2001 catcher vessel conditions reveals that under FMP 2.1 there would be a significant increase in retained harvests of pollock and Pacific cod relative to the comparative baseline. The large projected increase in the TAC for these species and the removal of PSC limits are expected to increase catches of pollock and Pacific cod by about 48 percent and 188 percent, respectively. Retained harvests of A-R-S-O species are also expected to increase significantly.

Ex-Vessel Value

As a result of the predicted increases in harvest tonnage of groundfish species, the ex-vessel value of groundfish landed by catcher vessels is expected to increase significantly relative to the comparative baseline. Increased pollock harvests by the three classes of AFA-eligible trawl catcher vessels account for much of the increase in groundfish ex-vessel value. In addition, a significant increase in ex-vessel value is expected for small trawl catcher vessels and fixed-gear vessels, largely through an increase in the harvest of Pacific cod and species in the A-R-S-O complex.

Employment and Payments to Labor

Total groundfish employment and payments to labor by catcher vessels are expected to increase significantly under FMP 2.1.

Impacts on Excess Capacity

FMP 2.1 is expected to substantially increase the quantity of catch and products from the groundfish fisheries. Therefore, a decrease in the level of excess capacity in the harvesting sector is predicted in the short-term. However, because FMP 2.1 repeals all effort limitation programs other than those that are statutorily-mandated, excess capacity in the harvesting sector is expected to significantly increase over the long-term as new vessels and processing facilities enter the groundfish fisheries with a significantly adverse effect in comparison to the baseline condition.

Average Costs

It is difficult to determine the net effect of various influences on average costs, and it will likely vary by fishery and species. Overall, however, a significant increase in average costs is expected under FMP 2.1 relative to the comparative baseline. In the short-term, average costs per unit of catch for some catcher vessels can be expected to decrease somewhat under FMP 2.1 due to the increase in the overall level of production resulting from the increased TAC and elimination of PSC limits. Many costs are fixed (e.g., loan repayments, general office and accounting expenses and insurance costs); they do not change with the level of production. These costs would be allocated to a larger amount of product, thereby lowering the average cost per unit of catch. However, over the long-term it is expected that catch per unit of effort will decrease

as harvest levels increase and capital expenditures will increase with the entry of new vessels and intensification of the race for fish. As a result, any cost savings under this FMP would likely be negated.

Variable costs will increase with the increase in catch, and the increase in the supply of fish is likely to put downward pressure on ex-vessel prices. The extent to which processors versus catcher vessels would share changes in harvesting costs and the extent to which catcher vessels are willing to accept lower prices as total supply increases will depend on their relative bargaining power as well as price elasticities of the products made from the fish. However, large decreases in ex-vessel prices and the associated variable costs of production for processors are not expected under FMP 2.1.

Elimination of the current VMS requirement may have a adverse impact on the fishing industry, as it could lead to the closure of all Steller sea lion critical habitat to fishing. By allowing NOAA Fisheries to effectively monitor compliance with a large number of complex area-based fishing restrictions, VMS affords vessels an opportunity for continued access to some historic fishing grounds within critical habitat. In the absence of VMS, it is possible that all critical habitat would have to be closed to fishing should it be determined by NOAA Fisheries that effective monitoring of the remaining Steller sea lion protection measures is no longer possible. The results of such a closure would be an increase in vessel travel time and higher operating costs.

The economic advantage conferred on some sectors of the groundfish fisheries by the elimination of PSC limits would come at the expense of other domestic fisheries in the region. Specifically, the increase in prohibited species bycatch would impose economic costs on harvesters and processors of crab, halibut, herring, and salmon in the form of foregone catches and product. No estimates of these losses under FMP 2.1 are available. However, it is estimated that increased gross revenue in groundfish fisheries would exceed the value of losses incurred in directed fisheries for halibut, salmon, and crab.

Fishing Vessel Safety

It is expected that FMP 2.1 will have both significantly beneficial and adverse effects on fishing vessel safety. However, it is uncertain whether the beneficial effects would outweigh the adverse effects. On the one hand, the increased competition among fishermen is expected to increase the risks fishermen will take to harvest fish. The adverse effects would be particularly severe in the sablefish longline fishery because FMP 2.1 would eliminate the vessel safety benefits of the IFQ program. These benefits result from the elimination of the race for fish and the associated freedom to decide when to fish and at what rate to fish. On the other hand, because FMP 2.1 would remove some fishing restrictions in nearshore areas, it would allow vessels to spend more time fishing nearer to shore and would reduce the potential for the risk of accidents and injury due to hazardous weather and other conditions. This could be particularly true in southeast Alaska where repeal of the LLP would open all of the area east of 144°W longitude to trawling. Other beneficial safety effects are expected to be realized in the Bristol bay area with the opening of the Nearshore Bristol bay closures in areas 506 and 512; along the Aleutian Islands where the Chinook Savings Area, Herring Savings Area, and Red King Crab Closure area would be open; and around Kodiak with the opening of the Kodiak Type 1 and Type 2 Areas.

Cumulative Effects of FMP 2.1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects

are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish ex-vessel value, employment, payments to labor, excess capacity, average costs, and fishing vessel safety. For a summary of the direct/indirect and cumulative ratings see Table 4.6-6.

Groundfish Landings By Species Group

- **Direct/Indirect Effects.** There would be a significant increase in retained harvest of pollock and Pacific cod relative to the comparative baseline. Increased TAC and the removal of PSC limits are expected to increase catches of pollock and Pacific cod by about 48 percent and 188 percent respectively. Retained harvests of other groundfish species will also increase significantly.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990's, and the development of the Japanese surimi market. These effects contributed to increased demand for groundfish species. They are discussed in more detail under "Groundfish Landings By Species Group" at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1 under FMP 1.

- **Cumulative Effects.** Although there are currently downward trends in the commercial salmon and crab fisheries, the predicted increases in retained harvests under FMP 2.1 are high enough for many species (187 percent for Pacific cod and 48 percent for pollock) that they are expected to mitigate the reductions in other fisheries. While climate change may result in potential increases or decreases in fish populations or diversity as explained in more detail in Section 4.5.10, these effects are not expected to result in significant effects under FMP 2.1. Overall, significantly beneficial cumulative effects are expected under FMP 2.1.

Ex-Vessel Value

- **Direct/Indirect Effects.** The total ex-vessel value of groundfish landed by catcher vessels is expected to increase significantly under FMP 2.1, much of which is accounted for by increases in pollock harvests.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990's, and the development of the Japanese surimi market; and contributed to increased demand for groundfish species. These effects are discussed in more detail under "Groundfish Landings By Species Group" at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Significantly beneficial cumulative effects are expected for ex-vessel value under FMP 2.1. The significant increases in harvests of Pacific cod, pollock and the A-R-S-O complex (187.6 percent, 48.3 percent, and 17.9 percent, respectively) account for the significant increases in ex-vessel value. Other fisheries reductions are likely to be mitigated by these increases for vessels that participate in multiple fisheries.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Under FMP 2.1 employment and payments to labor are expected to be significantly beneficial (increases of 110 percent and 64 percent respectively) primarily due to the increases in harvest.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market; and contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** The increases in employment and payments to labor (64 percent for both) predicted under FMP 2.1 as a result of increases in TAC and removal of PSC limits are likely to result in significantly beneficial cumulative effects on employment and payments to labor. Potential increases in municipal or landings taxes in rural Alaska communities due to reductions in subsidies and power cost equalization programs could indirectly reduce payments to labor. Although reductions in the salmon and crab fisheries are adversely affecting employment and payments to labor in other fisheries, the increases predicted under FMP 2.1 are expected to mitigate these effects.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** A substantial increase in excess capacity is likely to result due to the repeals of all effort license limitation programs other than those statutorily mandated, with a significantly adverse effect in comparison to the baseline condition. For further details (see the Direct/Indirect section at the beginning of Section 4.6.9.1.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic

cod in the 1990s, and the development of the Japanese surimi market; and contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of 4.5.9.1.

- **Cumulative Effects.** Programs implemented to reduce excess capacity in the groundfish fishery such as the LLP, are eliminated under FMP 2.1 This could result in additional vessels entering the fishery thereby exacerbating existing overcapacity. This, in conjunction with the remaining excess capacity in other fisheries, results in significantly adverse cumulative effects under FMP 2.1 (see Appendix F-8 – Overcapacity Paper).

Average Costs

- **Direct/Indirect Effects.** A significant increase in average costs are expected though they will likely vary by fishery and by species, with a significantly adverse effect in comparison to the baseline condition. These variations are described in further detail in Section 4.6.9.1 under Direct /Indirect Effects on Average Costs above.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market; and contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** As described in detail under the direct/indirect discussion of average costs at the beginning of Section 4.6.9.1, multiple variables influence changes in average costs such as area closures, transit time, harvest levels, and the race for fish. Recent reductions in government subsidies and power cost sharing programs have caused communities to rely even more on fishing revenues. Thus, there is potential for fish taxes to be raised in upcoming years. This could result in higher average costs. Area closures for the salmon and crab fisheries have the same affects as do groundfish closures, often increasing transit time and operating costs. However, long-term projections suggest that catches per unit of effort will decrease as TACs and capital expenditures increase with the entry of new vessels and intensification of the race for fish. These new entries and the amplification of the race for fish, combined with the effects of other closures in directed fisheries for halibut, salmon, and crab will likely result in significantly adverse cumulative effects under FMP 2.1.

Fishing Vessel Safety

- **Direct/Indirect Effects.** Significantly beneficial and significantly adverse effects are anticipated due to the uncertainty of whether increased competition among fishermen is expected to increase their risks to harvest fish or whether benefits of reduced closures in nearshore areas would reduce safety risks. Details on these variables can be found under the direct/indirect effects discussion at the beginning of Section 4.6.9.1.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market; and contributed to increased demand for groundfish species. These effects are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Vessel safety is primarily a function of the race for fish, and of distance to fishing areas and sea conditions relative to vessel size. While additional closures that may result from management measures in other fisheries may increase the risk to fishermen, the reduction of nearshore closures under FMP 2.1 may reduce risks. However, the safety risks are particularly severe under the sablefish longline fishery as a result of the elimination of vessel safety benefits under the IFQ program under this FMP. Significantly beneficial or adverse cumulative effects could result under FMP 2.1.

Direct/Indirect Effects of FMP 2.2

The model and analytical framework used in the analysis of the effects of FMP 2.2 on the harvesting and processing sectors are described in Section 4.1.7.

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 catcher vessel conditions reveals that under FMP 2.2 there would be a significant increase in retained harvests of pollock and Pacific cod relative to the comparative baseline. The projected increase in the TAC for these species is expected to increase catches of pollock and Pacific cod by about 20 percent and 54 percent, respectively. Flatfish harvests are rated as insignificant under FMP 2.2.

Ex-Vessel Value

As a result of the predicted increases in harvest tonnage of groundfish species, the overall ex-vessel value of groundfish landed by catcher vessels is expected to increase significantly relative to the comparative baseline. Increased pollock harvests by the three classes of AFA-eligible trawl catcher vessels account for much of the increase in groundfish ex-vessel value. In addition, a significant increase in ex-vessel value is

expected for smaller trawl catcher vessels and pot catcher vessels, largely through an increase in the harvest of Pacific cod.

Employment and Payments to Labor

Total groundfish employment and payments to labor by catcher vessels are expected to increase under FMP 2.2, but the increase is of marginal significance.

Impacts on Excess Capacity

No significant change in excess harvesting capacity is expected to occur under FMP 2.2 relative to the comparative baseline. This FMP would maintain current measures to reduce excess capacity and the race for fish in the Alaska groundfish fisheries. Current measures that address overcapacity include the LLP; the sablefish longline fishery IFQ program, which includes provisions for community purchase of quota shares; the cooperatives established in the BSAI pollock fishery under the AFA, and the western Alaska CDQ program. These measures have been successful in limiting harvesting and processing capacity in Alaska groundfish fisheries, and further decreases in capacity in the BSAI pollock fishery and sablefish longline fishery are expected. However, no additional overcapacity measures would be implemented under this FMP. A recent report by Felthoven *et al.* (2002) indicates that significant excess capacity remains in several groundfish fisheries.

Average Costs

No significant change in average costs is expected to occur under FMP 2.2 relative to the comparative baseline. Average costs per unit of catch for catcher vessels can be expected to decrease somewhat under this FMP due to the increase in the overall level of production resulting from the increased TAC. Many costs are fixed (e.g., loan repayments, general office and accounting expenses and insurance costs); they are not reduced with the level of production. These costs would be allocated to a larger amount of product, thereby lowering the average cost per unit of catch. However, it is possible that catch per unit of effort will decrease as harvest levels increase. This would mitigate the cost savings discussed above. It is difficult to determine the net effect of these influences, and it will likely vary by fishery and species. Nevertheless, over the long-term average costs are not expected to change significantly.

Fishing Vessel Safety

No significant change in fishing vessel safety is expected to occur under FMP 2.2 relative to the comparative baseline. The risk to fishermen is expected to remain high under this FMP. This is in part due to regulations that require fishermen to operate farther from shore or in areas and seasons with more hazardous weather conditions. In particular, the existing area closures will continue to require smaller catcher vessels based out of the Alaska Peninsula, Aleutian Islands, and Kodiak communities to travel far to fish, exposing the vessels to additional safety risks. The continued use of the race for fish to allocate TAC and PSC limits among competing fishermen in some fisheries is also expected to have a adverse effect on fishing vessel safety.

Cumulative Effects of FMP 2.2

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on

catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish ex-vessel value, employment, payments to labor, excess capacity, average costs, and fishing vessel safety. For a summary of the direct/indirect and cumulative ratings see Table 4.6-6.

Groundfish Landings By Species Group

- **Direct/Indirect Effects.** A significant increase in retained harvest of pollock and Pacific cod relative to the comparative baseline is projected under FMP 2.2. Retained harvests of other groundfish species will also increase significantly.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. These effects contributed to increased demand for groundfish species. They are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1 under FMP 1.

- **Cumulative Effects.** Similar to FMP 1, the predicted increases in retained harvests under FMP 2.2 are marginal for most species, except Pacific cod. The reductions in other fisheries could adversely affect harvest levels in the groundfish fisheries. Overall, significantly beneficial cumulative effects are expected under FMP 2.2.

Ex-Vessel Value

- **Direct/Indirect Effects.** The total ex-vessel value of groundfish landed by catcher vessels is expected to increase significantly under FMP 2.2.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. These effects contributed to increased demand for groundfish species. They are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Significantly beneficial cumulative effects are expected for ex-vessel value under FMP 2.2. The significant increases in Pacific cod and pollock harvests (51 percent and 20

percent respectively) account for the significant increases in ex-vessel value. Given the decreases in state subsidies for power generation, education and municipal revenue sharing, the importance of fishing, especially in rural Alaska, is increasing. The decreases in state subsidies may however, result in increases in fish landing taxes which could reduce ex-vessel value. The 20 percent increase predicted for overall groundfish ex-vessel value under FMP 2.2, could mitigate these potential effects but that is not likely. Therefore, significantly beneficial cumulative effects are anticipated for ex-vessel value under FMP 2.2.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Under FMP 2.2, employment and payments to labor are expected to be significantly beneficial (increases of 19 percent and 22 percent respectively) primarily due to the increases in harvest.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of JV fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. These effects contributed to increased demand for groundfish species. They are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** The marginal increases predicted for employment and payments to labor under FMP 2.2 associated with increases in retained harvest, especially for Pacific cod. Potential increases in municipal or landings taxes in rural Alaska communities due to reductions in subsidies and power cost equalization programs could indirectly reduce payments to labor. Cumulative effects are likely to be significantly beneficial even though there are current reductions in other fisheries such as salmon and crab and potential increases in fish landing taxes resulting from decreased state and municipal subsidies.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** Changes in excess capacity are likely to be insignificant under FMP 2.2.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. These effects contributed to increased demand for groundfish species. They are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Excess capacity is not expected to change significantly under FMP 2.2. Although the license limitation efforts help to reduce capacity, it is still predicted to remain high in the groundfish fisheries. Excess capacity is likely to also remain in other fisheries unless management addresses this issue. Therefore, cumulative effects are likely to be insignificant and excess capacity will continue. For details see the Overcapacity Paper in Appendix F-8.

Average Costs

- **Direct/Indirect Effects.** Insignificant effects are expected to occur for average costs under FMP 2.2.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. These effects contributed to increased demand for groundfish species. They are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Average costs are not expected to change significantly from the baseline condition under FMP 2.2. Associated or shared costs with other fisheries will continue to have an affect on costs in the groundfish fishery. Recent reductions in government subsidies and power cost sharing programs have caused communities to rely even more on fishing revenues. Thus, there is potential for fish taxes to be raised in upcoming years. This could result in higher average costs. Similar to FMP 1, insignificant cumulative effects are likely under FMP 2.2.

Fishing Vessel Safety

- **Direct/Indirect Effects.** No significant effects on fishing vessel safety are expected to result from FMP 2.2.

- **Persistent Past Effects.** The persistent past effects include foreign fisheries exploitation, over-harvesting, expansion or development of commercial services and marine infrastructure in coastal communities, development of joint venture fisheries leading to the development of domestic fish harvesting and processing capacity, increased global demand for seafood, the collapse of Atlantic cod in the 1990s, and the development of the Japanese surimi market. These effects contributed to increased demand for groundfish species. They are discussed in more detail under Groundfish Landings By Species Group at the beginning of Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Vessel safety is primarily a function of the race for fish, and of distance to fishing areas and sea conditions relative to vessel size. Under FMP 2.2, no additional closures are to be implemented other than those that are in place under the baseline condition. Closures implemented through other fisheries may affect vessel safety in the groundfish fisheries, although these closures are not expected to result in a significant cumulative effect on vessel safety.

4.6.9.1.2 Catcher Processors

Direct/Indirect Effects of FMP 2.1

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 catcher processor conditions reveals that under FMP 2.1 there would be a significant increase in catches of all groundfish species or species groups relative to the comparative baseline. The large projected increase in the TAC for these species and the removal of PSC limits are expected to increase catches of flatfish, pollock, and Pacific cod by about 71 percent, 45 percent, and 30 percent, respectively. Harvests of A-R-S-O species are expected to increase around 23 percent.

Groundfish Gross Product Value

As a result of the predicted increases in harvest tonnage of groundfish species, the overall wholesale product value of groundfish processed by catcher processors is expected to increase significantly relative to the comparative baseline. This increase is the result of significant increases in the value of pollock products produced by surimi trawl catcher processors and fillet trawl catcher processors; flatfish products produced by head-and-gut trawl catcher processors; Pacific cod products produced by pot catcher processors, longline catcher processor and head-and-gut trawl catcher processors; and products from A-R-S-O species produced by head-and-gut trawl catcher processors and longline catcher processors.

Employment and Payments to Labor

Total groundfish employment and payments to labor by catcher processors are expected to increase significantly under FMP 2.1. Head-and-gut trawl catcher processors, surimi trawl catcher processors and fillet trawl catcher processors account for most of this increase.

Product Quality and Product Utilization Rate

No significant change in overall product quality or product utilization rate is expected to occur under FMP 2.1 relative to the comparative baseline. The product value for the BSAI pollock fishery is expected to remain high as a result of the establishment of the AFA cooperatives and end of the race for fish. These measures will also mitigate the effects of the elimination of IR/IU regulations. However, the resumption of the race for fish in the sablefish longline fishery could result in a decrease in the quality of sablefish product. Because

both the intensity of this adverse effect and the probability of its occurrence are uncertain, it is considered conditionally significant adverse.

Excess Capacity

As with catcher vessels, the repeal of all effort limitation programs other than those that are statutorily-mandated is expected to result in a significant increase in excess capacity in the harvesting sector in the long-run with a significantly adverse effect in comparison to the baseline condition.

Average Costs

As with catcher vessels, a significant increase in average costs is predicted under FMP 2.1 relative to the comparative baseline as a result of lower catches per unit of effort associated with higher TACs and because of the increase in capital expenditures with the entry of new vessels and intensification of the race for fish. Thus, there would be a significantly adverse effect under FMP 2.1.

Fishing Vessel Safety

As with catcher vessels, either a significant improvement or reduction in fishing vessel safety could occur under FMP 2.1 relative to the comparative baseline. On the one hand, the increased competition among fishermen is expected to increase the risks fishermen will take to harvest fish. On the other hand, because FMP 2.1 would remove some fishing restrictions in nearshore areas, it would allow vessels to spend more time fishing nearer to shore and would reduce the potential for the risk of accidents and injury due to hazardous weather and other conditions. Thus a significantly adverse or beneficial effect on fishing vessel safety would be expected under FMP 2.1.

Cumulative Effects of FMP 2.1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish gross product value, employment, payments to labor, excess capacity, product quality, product utilization rate, average costs, and fishing vessel safety.

Groundfish Landings By Species Group

- **Direct/Indirect Effects.** Overall, significantly beneficial effects are expected for retained harvests of groundfish species.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue and are described in detail in Section 4.5.9.1.

- **Cumulative Effects.** Although there are currently downward trends in the commercial salmon and crab fisheries, the predicted increases in retained harvests under FMP 2.1 are high enough for many species (23 to 71 percent) that they are expected to mitigate the reductions in other fisheries. Overall, significantly beneficial cumulative effects are expected under FMP 2.1. Other economic development activities and other sources of municipal and state revenue are not expected to offset the large increases in TAC in the groundfish fishery. While climate change may result in potential increases or decreases in fish populations as explained in more detail in Section 4.5.10, these changes are not expected to have significant cumulative effects on groundfish landings by species group.

Groundfish Gross Product Value

- **Direct/Indirect Effects.** The gross product value is expected to increase significantly from the baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on landing tax revenues from non-groundfish fisheries (such as salmon, crab, and halibut). During recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing. Significantly beneficial cumulative effects are expected for gross product value under FMP 2.1. The significant increases in harvests of pollock, flatfish and Pacific cod, in particular, account for the significant increases in value. Other fisheries reductions are likely to be mitigated by these increases for vessels that participate in multiple fisheries.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Significant increases in employment and payments to labor are predicted for catcher processors under FMP 2.1.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** The current reductions in the salmon and crab fisheries, and the fact that many fishermen rely on participation in multiple fisheries may elevate the importance of participation in the groundfish fisheries. The increase in groundfish employment (44 percent) under FMP 2.1, is so

significant that it is likely to mitigate some of the reductions in other fisheries. Similarly, payments to labor are also projected to increase (39 percent) under FMP 2.1 thereby mitigating some of the reductions in other fisheries. Potential increases in municipal or landings taxes in rural Alaska communities due to reductions in subsidies and power cost equalization programs could indirectly reduce payments to labor, though this is not likely to have a strong effect under FMP 2.1. Therefore, significantly beneficial cumulative effects on employment and payments to labor are anticipated under FMP 2.1.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects.** Overall, insignificant effects in product quality and product utilization rates are expected under FMP 2.1 relative to the baseline. However, the resumption of the race for fish in the sablefish longline fishery could result in a decrease in the quality of sablefish product. Because both the intensity of this adverse effect and the probability of its occurrence are uncertain, it is considered conditionally significant adverse.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed under the Section 4.5.9.1.

- **Cumulative Effects.** Advances in technology have improved product quality and utilization for various fisheries throughout the world. However, the resumption of the sablefish longline fishery could result in decreased product quality. Overall, increases in product quality and utilization are likely in the long-term, though these improvements are not likely to result in significant cumulative effects under FMP 2.1. Due to the uncertainty of the intensity this effect may have on the groundfish fisheries, conditionally significant adverse cumulative effects may occur under FMP 2.1.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** Significantly adverse effects in excess capacity are expected under FMP 2.1 relative to the baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of 4.5.9.1.

- **Cumulative Effects.** Excess capacity still remains in other fisheries as well as the groundfish fishery. Measures such as LLP are repealed under FMP 2.1, which is likely to exacerbate the race for fish (Overcapacity Paper Appendix F-8). Given that effort limitation programs are discontinued under this FMP and excess capacity in other fisheries remains, significantly adverse cumulative effects are expected for excess capacity as it is expected to worsen from the baseline level.

Average Costs

- **Direct/Indirect Effects.** Significantly adverse effects in average costs are expected under FMP 2.1 relative to the comparative baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** As stated above in Section 4.6.9.1, average costs in the groundfish fisheries are often associated or shared with other fisheries. Fixed costs are somewhat independent of the fisheries in that loan payments and general office and accounting expenses remain at a certain amount while ex-vessel value and product value are variable. Increases in closure areas increase costs, whereas decreases in closures usually decrease costs. Depending on area closures or the fixed or variable costs in other fisheries, when considered in combination with average costs in the groundfish fishery, cumulative effects may result. Should costs in other fisheries increase or decrease, vessels that are dependent on multiple fisheries are often sensitive to these changes. As FMP 2.1 results in a reduction in closures, except for Steller sea lion related measures, cumulative effects on average costs in the groundfish fisheries could be reduced. However, the resumption of the race for fish is likely to increase costs. The expansion of the race for fish, in conjunction with potential increases in closed areas in other fisheries, result in significantly adverse cumulative effects for average costs.

Fishing Vessel Safety

- **Direct/Indirect Effects.** Significantly beneficial and significantly adverse effects are anticipated due to the uncertainty of whether increased competition among fishermen is expected to increase their risks to harvest fish or whether benefits of reduced closures in nearshore areas would reduce safety risks.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** As vessel safety is primarily a function of the race for fish, distance to fishing areas and sea conditions relative to vessel size, the reduction in closures under FMP 2.1 are expected to improve vessel safety. However, the race for fish under FMP 2.1 could result in increased risks to vessels. Significantly adverse or beneficial cumulative effects could result under FMP 2.1.

Direct/Indirect Effects of FMP 2.2

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 catcher processor conditions reveals that under FMP 2.2 there would be a significant overall increase in catches of groundfish species. As a result of a projected increase in the TAC, catches of flatfish and pollock are expected to increase by about 44 percent and 19 percent, respectively. Harvests of Pacific cod are expected to increase around 39 percent.

Groundfish Gross Product Value

As a result of the predicted increases in harvest tonnage of groundfish species, the overall wholesale product value of groundfish processed by catcher processors is expected to increase significantly relative to the comparative baseline. This increase is the result of significant increases in the value of pollock products produced by surimi trawl catcher processors and fillet trawl catcher processors; flatfish products produced by head-and-gut trawl catcher processors; and Pacific cod products produced by pot catcher processors, longline catcher processor and head-and-gut trawl catcher processors.

Employment and Payments to Labor

Total groundfish employment and payments to labor by catcher processors are expected to increase under FMP 2.2, but the increase is of marginal significance. Head-and-gut trawl catcher processors, surimi trawl catcher processors and fillet trawl catcher processors account for most of this increase.

Product Quality and Product Utilization Rate

No significant change in overall product quality or product utilization rate is expected to occur under FMP 2.2 relative to the comparative baseline.

Excess Capacity

As with catcher vessels, no significant change in excess harvesting capacity is expected to occur under FMP 2.2 relative to the comparative baseline. This FMP would maintain current measures to limit capacity and reduce the race for fish in the Alaska groundfish fisheries.

Average Costs

As with catcher vessels, no significant change in average costs is expected to occur under FMP 2.2 relative to the comparative baseline. Fixed costs per ton will decline as catches increase; however, variable cost per ton is expected to increase as the average catch per unit of effort declines in response to higher harvest levels.

Fishing Vessel Safety

As with catcher vessels, no significant change in fishing vessel safety is expected to occur under FMP 2.2 relative to the comparative baseline.

Cumulative Effects of FMP 2.2

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect (Table 4.6-6). The persistent past effects on catcher vessels are presented in detail in Section 3.9 and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish gross product value, employment, payments to labor, excess capacity, product quality, product utilization rate, average costs, and fishing vessel safety.

Groundfish Landings By Species Group

- **Direct/Indirect Effects.** Significantly beneficial effects are expected for groundfish landings by species group under FMP 2.2.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue and are described in detail in Section 4.5.9.1.

- **Cumulative Effects.** Although there are currently downward trends in the commercial salmon and crab fisheries, catcher processors that rely on a mix of groundfish, salmon and crab may experience a reduction in harvest levels. However, this reduction may be offset by the predicted increases in TAC for flatfish, pollock and Pacific cod. Other economic development activities and other sources of municipal and state revenue are not expected to contribute to cumulative effects on groundfish landings by species group. Significantly beneficial cumulative effects are projected for FMP 2.2.

Groundfish Gross Product Value

- **Direct/Indirect Effects.** The gross product value is expected to increase significantly from the baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on landing tax revenues from groundfish and non-groundfish fisheries (such as salmon, crab, and halibut). Although during recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing, the increases in product value projected under FMP 2.2 are likely to offset these reductions. Significantly beneficial cumulative effects for groundfish gross product value are anticipated under FMP 2.2.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Significantly beneficial effects are predicted for catcher processors under FMP 2.2.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** The increase in groundfish employment (23 percent) under FMP 2.2, is likely to mitigate some of the current reductions in other fisheries such as crab and salmon. Similarly, payments to labor are also projected to increase (23 percent) under FMP 2.2, thereby mitigating some of the reductions in other fisheries. Therefore, cumulative effects on employment and payments to labor are expected to be significantly beneficial under FMP 2.2.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects.** No significant changes in product quality or utilization rate are expected under FMP 2.2 relative to the baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings By Species Group.

- **Cumulative Effects.** As stated under FMP 2.1, advances in technology have improved product quality and utilization for various fisheries throughout the world. Overall, increases in product quality and utilization are likely in the long-term though these improvements are not expected to result in significant cumulative effects under FMP 2.2.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** No significant changes in excess capacity are expected under FMP 2.2 relative to the baseline. Current measures to reduce excess capacity and the race for fish would be maintained.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings By Species Group.

- **Cumulative Effects.** Although excess capacity still remains in other fisheries as well as the groundfish fishery, measures such as LLP and an end to the race for fish help mitigate this effect (Overcapacity Paper Appendix F-8). Assuming that these programs continue in other fisheries, as they do in the groundfish fisheries under FMP 2.2, no cumulative effects are expected for excess capacity as conditions are not expected to change significantly from the baseline.

Average Costs

- **Direct/Indirect Effects.** No significant change in average costs are expected under FMP 2.2 relative to the comparative baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings By Species Group.

- **Cumulative Effects.** As stated under FMP 2.1, average costs in the groundfish fisheries are often associated or shared with other fisheries. Fixed and variable costs, as well as area closures also have an effect on average costs. In contrast to FMP 2.1, closures do not change significantly from the baseline condition, and although fixed costs per ton decline as catch increases, variable costs per ton will increase. Insignificant cumulative effects on average costs in the groundfish fisheries are likely under FMP 2.2.

Fishing Vessel Safety

- **Direct/Indirect Effects.** No significant change in fishing vessel safety is expected under FMP 2.2.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed Section 4.5.9.1.

- **Cumulative Effects.** Vessel safety is primarily a function of the race for fish, distance to fishing areas and sea conditions relative to vessel size. Additional closures that may result from other fisheries management measures may increase the risk to fishermen, however, these effects are not expected to be significant under FMP 2.2. As there are no predicted increases in area closures under FMP 2.2, cumulative effects on vessel safety are insignificant compared to the baseline condition.

4.6.9.1.3 Inshore Processors and Motherships

Direct/Indirect Effects of FMP 2.1

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 inshore plant and mothership conditions reveals that under FMP 2.1 there would be a significant increase in catches of pollock and Pacific cod relative to the comparative baseline. The large projected increase in the TAC for these species and the removal of PSC limits are expected to increase catches of pollock and Pacific cod by about 48 percent and 179 percent, respectively. Catches of A-R-S-O species are also expected to increase significantly.

Groundfish Gross Product Value

As a result of the predicted increases in harvest tonnage of groundfish species, the overall wholesale product value of groundfish processed by inshore plants and motherships is expected to increase significantly relative to the comparative baseline. Increased deliveries of pollock and Pacific cod to Bering Sea pollock shore plants account for much of the increase in product value. However, the product value of all inshore processing plants and motherships is expected to increase significantly as a result of the overall increase in groundfish catch.

Employment and Payments to Labor

Total groundfish employment and payments to labor by inshore plants and motherships are expected to increase significantly under FMP 2.1. Bering Sea pollock shore plants account for most of the increase in employment and payments to labor.

Product Quality and Product Utilization Rate

As with catcher processors, no significant change in overall product quality or product utilization rate is expected to occur under FMP 2.1 with the exception of sablefish. The resumption of the race for fish in the sablefish longline fishery could result in a decrease in the quality of sablefish product. Because both the intensity of this adverse effect and the probability of its occurrence are uncertain, it is considered conditionally significant adverse.

Excess Capacity

In general, the increase in the TAC under FMP 2.1 will mean a significant reduction in excess processing capacity as throughput increases. In contrast to catcher vessels and catcher processors, the repeal of effort limitation measures is not expected to a substantial and rapid increase in the capacity of inshore processing facilities because those measures were not directed at controlling processing capacity.

Average Costs

In contrast to the harvesting sector, the inshore processing sector is expected to realize a significant decrease in average costs under FMP 2.1 relative to the comparative baseline. Higher catches in the groundfish

fisheries and a larger number of fishing vessels will likely eliminate upward pressure on ex-vessel prices, and greater throughput over constant fixed costs will result in significantly lower average costs for processing facilities.

Cumulative Effects of FMP 2.1

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish gross product value, employment, payments to labor, excess capacity, product quality, product utilization rate, average costs, and fishing vessel safety.

Groundfish Landings By Species Group

- **Direct/Indirect Effects.** Overall, retained harvests of groundfish species are expected to be significantly beneficial with increases in retained groundfish harvests for certain species.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue and are described in detail in Section 4.5.9.1.

- **Cumulative Effects.** Although there are downward trends in the commercial salmon and crab fisheries, inshore plants and motherships are projected to experience such increases in groundfish harvests that significantly beneficial cumulative effects are anticipated under this FMP. Other economic development activities and other sources of municipal and state revenue can have an effect on the processing plants through landings taxes and other tax mechanisms, however, these are not expected to have significant effects under FMP 2.1.

Groundfish Gross Product Value

- **Direct/Indirect Effects.** The gross product value is expected to increase significantly from the baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on landing tax revenues from groundfish and non-groundfish

fisheries (such as salmon, crab, and halibut). Although during recent years, state municipal revenue sharing, power cost equalization, and contribution to education programs have been decreasing, the dramatic increases in gross product value (62 percent) predicted under FMP 2.1 are likely to result in significantly beneficial cumulative effects.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Significantly beneficial effects are predicted for catcher processors under FMP 2.1.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** The increase in groundfish employment (64 percent) under FMP 2.1, is likely to mitigate some of the reductions currently taking place in other fisheries such as salmon and crab. Similarly, payments to labor are also projected to increase (63 percent) under FMP 2.1. Potential increases in municipal or landings taxes in rural Alaska communities due to reductions in subsidies and power cost equalization programs could indirectly reduce payments to labor, though this is not likely to have a strong effect under FMP 2.1. Therefore, significantly beneficial cumulative effects on employment and payments to labor are expected under FMP 2.1.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects.** Insignificant changes in product quality or utilization rate are expected under FMP 2.1 relative to the baseline. However, the resumption of the race for fish in the sablefish longline fishery could result in a decrease in the quality of sablefish product. Because both the intensity of this adverse effect and the probability of its occurrence are uncertain, it is considered conditionally significant adverse.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** Advances in technology have improved product quality and utilization for various fisheries throughout the world. However, the resumption of the sablefish longline fishery could result in decreased product quality. Overall, increases in product quality and utilization are likely in the long-term though these improvements are not likely to result in significant cumulative effects under FMP 2.1. Due to the uncertainty of the intensity this effect may have on the groundfish fisheries, conditionally significant adverse cumulative effects may occur under FMP 2.1.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** Significantly beneficial effects in excess capacity are expected under FMP 2.1 relative to the baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** The increase in throughput is expected to result in significantly beneficial cumulative effects (Appendix F-8 Overcapacity Paper).

Average Costs

- **Direct/Indirect Effects.** Significantly beneficial effects in average costs are expected under FMP 2.1 relative to the comparative baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** As stated in Section 4.6.9.1, average costs in the groundfish fisheries are often associated or shared with other fisheries. Fixed costs are somewhat independent of the fisheries in that loan payments and general office and accounting expenses remain at a certain amount while product value is variable. In contrast to the harvesting sector, processors that have greater throughput over fixed costs have lower costs as a result. As FMP 2.1 is projected to result in greater throughput for inshore processors and motherships, significantly beneficial cumulative effects are likely. Average costs are expected to be reduced under this FMP.

Direct/Indirect Effects of FMP 2.2

Groundfish Landings By Species Group

A comparison of the 5-year average of outcomes projected for the 2003-2007 period to the 2001 inshore plant and mothership conditions reveals that under FMP 2.2 there would be a significant increase in catches of pollock and Pacific cod relative to the comparative baseline. The projected increase in the TAC for these species is expected to increase catches of pollock and Pacific cod by about 21 percent and 49 percent, respectively.

Groundfish Gross Product Value

As a result of the predicted increases in harvest tonnage of groundfish species, the overall wholesale product value of groundfish processed by inshore plants and motherships is expected to increase significantly relative to the comparative baseline. Increased deliveries of pollock and Pacific cod to Bering Sea pollock shore plants account for much of the increase in product value.

Employment and Payments to Labor

Total groundfish employment and payments to labor by inshore plants and motherships are expected to increase under FMP 2.2, but the increase is of marginal significance.

Product Quality and Product Utilization Rate

No significant change in overall product quality or product utilization rate is expected to occur under FMP 2.2 relative to the comparative baseline.

Excess Capacity

Because processing amounts are expected to increase substantially with the increase in TAC, excess capacity in the inshore processing sector is expected to significantly decrease.

Average Costs

Average costs are expected to decline significantly in the inshore processing sector, as fixed costs are spread over greater throughput amounts. Unlike harvesters, inshore processors are not expected to experience higher variable costs. Rather, economies of scale within this sector are likely to result in lower average variable costs.

Cumulative Effects of FMP 2.2

This section will assess the potential for the direct/indirect effects to interact with persistent past effects and other reasonably foreseeable future events, resulting in a cumulative effect. The persistent past effects on catcher vessels are presented in detail in Section 3.9 (Table 3.9-125) and the predicted direct/indirect effects are described above. Representative indicators for direct/indirect effects include groundfish landings by species group, groundfish gross product value, employment, payments to labor, excess capacity, product quality, product utilization rate, average costs, and fishing vessel safety.

Groundfish Landings By Species Group

- **Direct/Indirect Effects.** Overall, retained harvests of groundfish species are expected to increase significantly compared to the baseline with increases of 49 percent for Pacific cod and 21 percent for pollock.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue and are described in detail in Section 4.5.9.1.

- **Cumulative Effects.** As stated under FMP 2.1, the current downward trends in the commercial salmon and crab fisheries, catcher vessels that rely on a mix of groundfish, salmon and crab may result in reduction in harvest levels. However, the increases in harvest projected for groundfish species under FMP 2.2 are likely to mitigate some of these reductions and result in significantly beneficial cumulative effects for groundfish landings. Although other economic development activities and other sources of municipal and state revenue can indirectly affect processors due to recent reductions in government subsidies and power cost sharing programs, these effects are not expected to be significant under FMP 2.2.

Groundfish Gross Product Value

- **Direct/Indirect Effects.** The gross product value is expected to increase significantly, especially for Bering Sea pollock shore plants.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** Changes in revenue streams that affect the ability of communities to provide municipal services, fund capital projects, borrow money, and retire or service debt have the greatest potential for cumulative effects on landing tax revenues from groundfish and non-groundfish fisheries (such as salmon, crab, and halibut).The recent decline in state municipal revenue sharing, power cost equalization, and contribution to education programs have is not expected to offset the significant increases in gross product value predicted under FMP 2.2 due primarily to the increases in pollock and Pacific cod in the Bering Sea. For these reasons, significantly beneficial cumulative effects on gross product value are expected to result from FMP 2.2.

Employment and Payments to Labor

- **Direct/Indirect Effects.** Significantly beneficial effects are predicted for inshore processors and motherships under FMP 2.2.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed at the beginning of Section 4.5.9.1.

- **Cumulative Effects.** Although reductions in the salmon and crab fisheries are currently taking place, the increase in groundfish employment (22 percent) under FMP 2.2 is likely to mitigate some of the reductions in these other fisheries. Similarly, payments to labor are also projected to increase (21 percent) under FMP 2.2 thereby mitigating some of the reductions in other fisheries Therefore, cumulative effects on employment and payments to labor are expected to be significantly beneficial under FMP 2.2.

Product Quality and Product Utilization Rate

- **Direct/Indirect Effects.** No significant changes in product quality or utilization rate are expected under FMP 2.2 relative to the baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings By Species Group.

- **Cumulative Effects.** Advances in technology have improved product quality and utilization for various fisheries throughout the world. The end of the race for fish has also made significant differences in product quality and utilization, however, the continuation of this harvest strategy may hinder some of these improvements. Overall, increases in product quality and utilization are likely in the long-term though these improvements are not likely to result in significant cumulative effects under FMP 2.2.

Impacts on Excess Capacity

- **Direct/Indirect Effects.** Significantly beneficial effects on excess capacity are expected under FMP 2.2 due to the increases in processing amounts.

- **Persistent Past Effects.** For details on persistent past effects see the beginning of 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed above under the section Groundfish Landings By Species Group.

- **Cumulative Effects.** Although excess capacity still remains in other fisheries as well as the groundfish fishery, measures such as LLP and an end to the race for fish help mitigate this effect (Appendix F-8 Overcapacity Paper). The continuation of these programs in conjunction with increased TAC and retained harvests projected for FMP 2.2, significantly beneficial cumulative effects are expected.

Average Costs

- **Direct/Indirect Effects.** Significantly beneficial effects in average costs are expected under FMP 2.2 relative to the comparative baseline.

- **Persistent Past Effects.** For details on persistent past effects see Section 4.5.9.1 Groundfish Landings By Species Group.

- **Reasonably Foreseeable Future External Effects** include other fisheries, other economic development activities, and other sources of municipal and state revenue. Details on these future external effects are listed in Section 4.5.9.1.

- **Cumulative Effects.** As described under FMP 2.1, average costs in the groundfish fisheries are often associated or shared with other fisheries. As fixed costs are spread over a greater amount of throughput under FMP 2.2, they are likely to decrease significantly. Similar to FMP 1, closures do not change significantly from the baseline condition, therefore cumulative effects on average costs in the groundfish fisheries are expected to be significantly beneficial.

4.6.9.2 Regional Socioeconomic Effects

The predicted direct and indirect effects of the groundfish fishery under Alternative 2 (FMP 2.1 and FMP 2.2) are described below. The past/present effects on regions that participate in the groundfish fishery are described in Section 3.9 (Table 3.9-126) and below; these regions (illustrated in Figures 3.9-9 through 3.9-13) include:

- Aleutian Islands/Alaska Peninsula (comprised of the Aleutians East Borough and the Aleutians West Census Area, which includes the communities of Unalaska, Nikolski, Atka, Adak and the Pribilof Islands).

- Kodiak Island (Kodiak Island Borough, which includes the City of Kodiak).

- Southcentral Alaska (the Kenai Peninsula Borough, Matanuska-Susitna Borough, Municipality of Anchorage, and the Valdez-Cordova Census Area, which includes the PWS region).

- Southeast Alaska (from Yakutat Borough to Dixon Entrance).

- Washington inland waters (all counties bordering Puget Sound and the Strait of Juan de Fuca).

- Oregon coast (Lincoln, Tillamook, and Clatsop counties).

This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. Due to the linkages of potential effects on regions that participate in the groundfish fishery to changes in harvest and processing levels under each of the policy alternatives and illustrative bookends, the direct and indirect effects of each alternative are based on an economic model that distributes potential effects to each of the participating regions. The indicators used to assess potential regional effects include the following:

- In-region Processing and Related Effects.
- Regionally Owned At-Sea Processors.
- Extra-regional Deliveries of regionally Owned Catcher Vessels.
- In-region Deliveries of regionally Owned Catcher Vessels.
- Total Direct, Indirect, and Induced Labor Income and FTE's.

As discussed earlier, these indicators also reflect changes in other important regional characteristics such as secondary economic activity associated with the support of fishing, state and municipal revenue generated by fishing, and indirectly population, to the extent that it is related to employment opportunities. For more information on the economic model used to assess direct and indirect regional effects (see the analysis for FMP 1 and Section 4.1.7 of the document).

Direct and Indirect Effects of FMP 2.1

Policy Alternative 2 removes or reduces some of the controls of the groundfish fishery, eliminates CDQ quotas, increases TAC, and represents a more aggressive harvest strategy. Under FMP 2.1, in general there is a strong net overall increase in fishery socioeconomic indicator values over baseline conditions for all regions. For example, total value of processing sales increases by about 52 percent over baseline conditions, while total processing and harvesting related income and employment increase by 53 and 56 percent, respectively, for all regions combined. These changes are driven to a large degree by the expansion of the pollock fishery, but essentially all values increase to some extent as a result of a more aggressive harvest strategy (higher TACs) and a removal of PSC limits. Elimination of the CDQ multi-species groundfish program also serves to increase overall TAC for relevant species for the non-CDQ portion of the fishery (while increases in the pollock fishery - and proportional increase of value of the CDQ portion of that fishery - would serve to offset losses from the discontinuation of the multi-species program to the CDQ region itself). Regional increases in the Alaska Peninsula and Aleutian Islands region are driven to a large degree by increased shoreplant activity (both pollock and Bering Sea cod), while Kodiak increases are driven by a mix of pollock, Pacific cod, and sablefish increases. The pattern for southcentral Alaska is similar to that seen for Kodiak while southeast changes are more directly attributable to sablefish by itself. The following subsections provide a region-by-region summary of change under FMP 2.1 as compared to the baseline.

Alaska Peninsula and Aleutian Islands. Under FMP 2.1, total in-region groundfish processing value would increase by 64 percent (with increases in both BSAI and GOA). In-region processing-associated labor income and FTE jobs would both increase by 64 percent. Regionally owned at-sea processing value (and associated payments to labor and FTEs) would decline sharply in percentage terms, but this is a very small sector in this region, with negligible impact on a regional basis. The value of extra-regional deliveries by regionally owned catcher vessels would increase by 40 percent and in-region deliveries would decrease, but by a less than significant amount. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 40 and 57 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs both would decrease by a less than significant amount, but for both extra-regional and in-region catcher vessel deliveries, the absolute values for this region are relatively small. With respect to the relative importance of the different sectors to net regional impacts, the in-region processing related activity accounts for the vast majority of fishery associated labor income and FTEs, so the increases seen in

processing values would be disproportionately important in relation to changes seen in the other sectors. (Further, in-region processing value may be taken as a proxy for regionally important municipal and borough revenues generated by local fish taxes.) The total regional direct, indirect, and induced labor income would increase by about 62 percent and FTE employment would increase by about 62 percent under this FMP (from a base of $226 million in labor income and 4,796 FTEs). FMP 2.1 has beneficial impacts for the Alaska Peninsula and Aleutian Islands region, and a number of these impacts are considered significant on a local sector and a regional (and multiple community) basis.

Kodiak Island. Total in-region groundfish processing value would increase by 57 percent (with higher values for GOA; BSAI values are not a significant portion of the regional total). Associated labor income and FTE jobs would also increase by 57 percent. Regionally owned at-sea processing value would increase (with the vast majority of the increase attributable to changes in BSAI values), as would associated labor income and FTEs, but none of these increases are large enough to be considered significant. (In this region under baseline conditions, in-region processing accounts for about three-quarters of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-quarter of the total; labor income and FTEs distribution between these processing sectors follows a similar pattern.) The value of extra-regional and in-region deliveries by regionally owned catcher vessels would increase by 170 and 78 percent, respectively. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 170 and 274 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would increase by about 78 and 99 percent, respectively, but over a smaller base than seen for extra-regional deliveries. On a regional basis, catcher vessel activity is a relatively more important component of fishery associated labor income and FTEs than was seen in the Alaska Peninsula/Aleutian Islands region, but processing activity still dominates these categories in the regional totals. The total regional direct, indirect, and induced labor income would increase by about 59 percent and FTE employment would increase by about 76 percent under this FMP (from a base of $65 million in labor income and 1,600 FTEs). FMP 2.1 has consistently beneficial impacts for the Kodiak Island region, and a number of these impacts are considered significant on a local sector and a regional (or at least the community of Kodiak) basis.

Southcentral Alaska. Total in-region groundfish processing value would increase by 104 percent (all attributable to GOA increases). Associated labor income and FTE jobs would also increase by 104 percent. Regionally owned at-sea processing value would increase by 78 percent (with increases in both BSAI values and GOA values), and associated labor income increasing by 78 percent and FTEs increasing by 79 percent. (In this region under baseline conditions, in-region processing accounts for about four-fifths of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-fifth of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea sector.) The value of extra-regional and in-region deliveries by regionally owned catcher vessels would increase by 116 and 124 percent, respectively. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 116 and 115 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would increase by about 124 and 137 percent, respectively. In this region, catcher vessel associated FTE jobs far surpass processing FTEs in the regional totals, but payments to labor for processing still surpass those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model clearly tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income would increase by about 103 percent and FTE employment would increase by about 107 percent (from a base of $23 million in labor income and 567 FTEs).

FMP 2.1 has consistently beneficial impacts for the southcentral Alaska region, and a number of these impacts are considered significant on a local sector basis. While some communities are likely to experience some noticeable benefits from these gains, on a regional basis (and in most involved communities), a relatively low level of groundfish dependency in local economies within this region tends to lessen what would otherwise appear to be a relatively large overall impact.

Southeast Alaska. Total in-region groundfish processing value would increase by 26 percent (all attributable to GOA decreases). Associated labor income and FTE jobs would also increase by 26 percent (but both are relatively low values). Regionally owned at-sea processing value would decrease by 49 percent (with decreases in BSAI values offset to a degree by increases in GOA values), and associated labor income and FTEs both decreasing by 49 percent. (In this region under baseline conditions, in-region processing accounts for about seven-tenths of the combined processing total value of sales and regionally owned at-sea processing accounts for about three-tenths of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea sector.) The value of extra-regional deliveries by regionally owned catcher vessels would increase by about 57 percent and in-region deliveries by regionally owned catcher vessels would increase by 24 percent. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 51 and 58 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would increase by about 24 and 25 percent, respectively. For this region, catcher vessel FTE employment far outpaces processing related employment, but payments to labor for processing still outpace those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income would increase, but not by a large enough amount to be considered significant, while FTE employment would increase by about 20 percent (from a base of $34 million in labor income and 879 FTEs). FMP 2.1 has consistently beneficial impacts for the southeast Alaska region, and a number of these impacts are considered significant on a local sector basis. As was the case for the southcentral Alaska region for this FMP, while some communities are likely to experience some noticeable benefits from these gains, on a regional basis (and in most involved communities), a relatively low level of groundfish dependency in local economies within the southeast Alaska region tends to lessen what would otherwise appear to be a relatively large overall impact.

Washington inland waters. Total in-region groundfish processing value changes are negligible on a regional basis due to low baseline values and small changes from the baseline. Associated labor income and FTE jobs would increase by large percentages, but their overall low value render these changes not significant. Regionally owned at-sea processing value would increase by 45 percent (with increases in both BSAI and GOA values, although GOA values are comparatively very small), and associated labor income and FTEs would increase by 43 and 49 percent, respectively. The value of extra-regional and in-region deliveries by regionally owned catcher vessels would increase by 58 and 55 percent, respectively. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 58 and 112 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would increase by about 55 and 131 percent, respectively. In this region, processing dominates the regional labor income and FTE employment totals when compared to analogous catcher vessel figures, but it is important to note that catcher vessel totals are still far higher for this region than for any other. The total regional direct, indirect, and induced labor income would increase by about 47 percent and FTE employment would also increase by about 47 percent (from a base of $557 million in labor income and 10,316 FTEs). FMP 2.1 has consistently beneficial impacts for the Washington inland waters region, and while a number of these impacts are

considered significant on a local sector basis, none are likely to be significant on a community or regional basis as a result of the relative size of the communities and the size and diversity of the local economy.

Oregon coast. Total in-region groundfish processing value changes are zero, along with associated labor income and FTE jobs, as there is no activity under baseline conditions or under this FMP. Similarly, there are no regionally owned at-sea processors under baseline conditions or foreseen under this FMP, so all processing values, labor income, and FTE job values are zero. The value of extra-regional deliveries by regionally owned catcher vessels would increase by 48 percent, and associated labor income and FTE jobs would increase 48 and 106 percent, respectively. There is no in-region activity by catcher vessels owned in this region, so all values for product, labor income, and FTE jobs are zero under both baseline conditions and this FMP. The total regional direct, indirect, and induced labor income would increase by about 48 percent and FTE employment would increase by about 73 percent (from a base of $15 million in labor income and 318 FTEs). FMP 2.1 has consistently beneficial impacts for the Oregon coast region and while some of these impacts may be considered significant on a local sector basis, none are considered significant on a community or regional basis due to a relatively low level of economic dependency on the groundfish fishery.

Cumulative Effects of FMP 2.1

See Table 4.6-6 for a summary of the cumulative effects on regions and communities under FMP 2.1.

In-Region Processing and Related Effects

- **Direct/Indirect Effects.** For FMP 2.1, direct/indirect effects are considered significantly beneficial for the Alaska Peninsula/Aleutian Islands, Kodiak Island, southcentral Alaska, and southeast Alaska regions. Direct/indirect effects are generally insignificant for the Washington inland waters, and Oregon coast regions.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.1, cumulative effects on in-region processing and related characteristics, such as municipal revenue and secondary economic development, are generally insignificant, although for different reasons in different regions. The influence of external factors is adverse for many of the in-region processors based in Alaska and their associated regions. Trends in multi-species fisheries and other sources of municipal and state revenue, primarily due to the continued crab closures, downturn in salmon and reductions in state and municipal revenue, result in adverse effects on in-region processing and municipal revenue. These adverse external effects are offset by significant increases in Alaska in-region processing, resulting in a finding of insignificant cumulative effect. For the Washington inland waters and Oregon coast regions, direct/indirect effects are insignificant, and there are no reasonably foreseeable events that would have a significant contribution, resulting in a finding of insignificant cumulative effect.

Regionally Owned At-Sea Processors

- **Direct/Indirect Effects.** Under FMP 2.1, direct/indirect effects are considered significantly beneficial for the southcentral Alaska and Washington inland waters regions. Direct/indirect effects are generally insignificant for the Alaska Peninsula/Aleutian Islands, Kodiak Island, and Oregon coast regions, and are significantly adverse for the southeast Alaska region.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and to a lesser extent, trends in state and municipal revenue. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.1, cumulative effects on regionally owned at-sea processing and on related characteristics, such as municipal revenue and secondary economic development, are generally insignificant. While direct/indirect effects are beneficial for southcentral Alaska and Washington inland waters regions, reasonably foreseeable external effects will not contribute much to cumulative effects, particularly given the size and diversity of the regional economies. Direct/indirect effects are insignificant in Kodiak Island, where most of the Alaska at-sea processor fleet is based. As indicated previously, with a more diversified economy and population base, cumulative effects in Kodiak Island will be adverse due to external factors, but cumulatively insignificant.

Extra-regional Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects.** Under FMP 2.1, direct and indirect effects are significantly beneficial for all six regions.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. Catcher vessels are affected by changes that have occurred in the groundfish industry related to allocation and AFA sideboards, and by their participation in multi-species fisheries, particularly salmon, crab, and halibut. For more detail, see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all FMPs; for more detail see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.1, significantly beneficial effects for all regions contribute to regional economies. However, given the size and diversity of some regional economies, and the adverse nature of external effects related to other fisheries and revenue sharing in the Alaska regions that offset benefits, cumulative effects are insignificant for all regions.

In-Region Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects.** Under FMP 2.1, direct/indirect effects are significantly beneficial for Kodiak Island, southcentral Alaska, southeast Alaska, and Washington inland waters; effects are insignificant for the Alaska Peninsula/Aleutian Islands, and Oregon coast regions.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all FMPs; for more detail see the discussion of persistent past effects under in-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.1 the direct/indirect effects range from beneficial to insignificant. However, given the size and diversity of some regional economies, and the adverse nature of external effects related to other fisheries and revenue sharing in the Alaska regions that offset benefits, cumulative effects are insignificant for all regions.

Total Direct, Indirect, and Induced Labor Income and FTEs

- **Direct/Indirect Effects.** Under FMP 2.1, direct/indirect effects on labor income and employment increase and are significantly beneficial for all regions, except for southeast Alaska, where the increase is insignificant.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, trends in state and municipal revenue, and public infrastructure and facility projects. Fishing is a major component of income and employment in many small Alaskan coastal communities. Federal, state, and local revenue has funded public infrastructure and facility projects that generate income and employment in many regions and communities. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all FMPs. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.1 direct/indirect effects on labor income and employment are significantly beneficial for all regions. Within southcentral Alaska, Washington inland waters, and Oregon coast regions, fisheries are a small part of the regional economies and effects are dwarfed by other trends. Trends in other fisheries (particularly salmon) and reductions in municipal revenue decrease labor income and employment and offset these benefits, particularly in the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Cumulative effects are beneficial, but insignificant in all regions.

Direct/Indirect Effects of FMP 2.2

Under FMP 2.2, in general fishery socioeconomic indicators fall in a range between the values seen under FMP 1 and those seen under FMP 2.1. Indicators at the most aggregated level are greater than baseline conditions for all regions. For example, total value of processing sales increases by about 22 percent over baseline conditions, while total processing and harvesting related income and employment increase by 22 and 19 percent, respectively, for all regions combined. Pollock and Pacific cod values are up overall, but the effects of this increase are most pronounced in the Alaska Peninsula and Aleutian Islands and Kodiak regions. Sablefish and rockfish increases play a large proportional role in the overall increases seen in the southcentral and southeast Alaska regions. One caveat to the data that appear in the regional summaries for this FMP, however, is that the model tends to overstate the increases seen in southcentral and understate the increases in southeast due to apportionment difficulties, so regional variations between these two should be treated with caution. (Overall values for the two regions combined are apparently accurate; it is the split between the two that is problematic.) As with FMP 2.1, essentially all socioeconomic indicator values increase to some extent as a result of a more aggressive harvest strategy compared to baseline conditions. Unlike FMP2.1, however, the CDQ multi-species groundfish program continues unchanged from baseline conditions under FMP 2.2. The following subsections provide a region-by-region summary of change under FMP 2.2 as compared to the baseline.

Alaska Peninsula and Aleutian Islands. Under FMP 2.2, total in-region groundfish processing value would increase by 24 percent (with increases in both BSAI and GOA values). In-region processing associated labor income and FTE jobs would also increase by 24 percent. Regionally owned at-sea processing value (and associated payments to labor and FTEs) would increase in percentage terms, but this is a very small sector in this region, with negligible impact on a regional basis. The value of extra-regional deliveries by regionally owned catcher vessels would remain the same and in-region deliveries would decrease, but by an amount that is considered less than significant. Catcher vessel payments to labor would remain the same and FTE jobs associated with extra-regional deliveries would decrease, but not to a significant degree. For in-region deliveries, catcher vessel payments to labor and FTEs would also decrease (by a less than significant amount), but for both extra-regional and in-region catcher vessel deliveries, the absolute values for this region are relatively small. With respect to the relative importance of the different sectors to net regional impacts, the in-region processing related activity accounts for the vast majority of fishery associated labor income and FTEs, so the increases seen in processing values would be disproportionately important in relation to changes seen in the other sectors. (Further, in-region processing value may be taken as a proxy for regionally important municipal and borough revenues generated by local fish taxes.) The total regional direct, indirect, and induced labor income would increase by about 24 percent and FTE employment would increase by 23 percent under this FMP (from a base of $226 million in labor income and 4,796 FTEs). FMP 2.2 would result in beneficial impacts for the Alaska Peninsula and Aleutian Islands region, and a number of these impacts would be considered significant on a local sector and a regional (and multiple community) basis.

Kodiak Island. Total in-region groundfish processing value would increase (with high values for both GOA and BSAI; BSAI values are not a significant portion of the regional total) as would associated labor income and FTE jobs, but these increases would not rise to the level of significance. Regionally owned at-sea processing value would increase by 25 percent (with the vast majority of the increase attributable to changes in BSAI values), and associated labor income and FTEs would increase by 24 and 25 percent, respectively. (In this region under baseline conditions, in-region processing accounts for about three-quarters of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-

quarter of the total; labor income and FTEs distribution between these processing sectors follow a similar pattern.) The value of extra-regional deliveries by regionally owned catcher vessels would increase by 32 percent, and while in-region deliveries would also increase, this increase would not be significant. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 32 and 38 percent, respectively. For in-region deliveries, catcher vessel payments to labor would increase and FTEs would decrease, but neither change would be significant (and would be over a smaller base than seen for extra-regional deliveries). On a regional basis, catcher vessel activity is a relatively more important component of fishery associated labor income and FTEs than was seen in the Alaska Peninsula/Aleutian Islands region, but processing activity still dominates these categories in the regional totals. The total regional direct, indirect, and induced labor income would increase as would FTE employment under this FMP (from a base of $66 million in labor income and 1,600 FTEs), but these changes would not rise to the level of significance. FMP 2.2 would generally result in beneficial impacts for the Kodiak Island region, and a number of these impacts would be considered significant on a local sector basis, but it would appear that the impacts, while beneficial, would be less than significant on a regional (or community of Kodiak) basis.

Southcentral Alaska. Total in-region groundfish processing value would increase by 34 percent (all attributable to GOA increases). Associated labor income and FTE jobs would also increase by 34 percent. Regionally owned at-sea processing value would increase by 34 percent (with relatively large increases in BSAI values and smaller increases in GOA values), and associated labor income and FTEs both increasing by 34 and 35 percent, respectively. (In this region under baseline conditions, in-region processing accounts for about four-fifths of the combined processing total value of sales and regionally owned at-sea processing accounts for about one-fifth of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea sector.) The value of extra-regional deliveries by regionally owned catcher vessels would increase, but by less than a significant amount, while in-region deliveries would rise by 41 percent. Catcher vessel payments to labor associated with extra-regional deliveries would increase and FTE jobs would decrease, but neither change would be significant. For in-region deliveries, catcher vessel payments to labor and FTEs would increase, but this change would also be less than significant. In this region, catcher vessel associated FTE jobs far surpass processing FTEs in the regional totals, but payments to labor for processing still surpass those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income would increase by about 31 percent and FTE employment would increase 22 percent (from a base of $23 million in labor income and 567 FTEs). FMP 2.2 would generally result in beneficial impacts for the southcentral Alaska region, and some of this rise to the level of significance on a local sector basis. As noted in the FMP 2.1 discussion, however, there are indications that the model overstates gains attributed to the southcentral and understates gains to the southeast Alaska region. Further, given the economic diversity of the involved southcentral communities and the relatively low level of groundfish dependency in the local economies, impacts that appear significant on a sector basis are not likely to be significant on a regional or even a community basis, with very few possible exceptions.

Southeast Alaska. Total in-region groundfish processing value would decrease by an insignificant amount (all attributable to GOA decreases), as would associated labor income and FTE jobs (but both are relatively low values). Regionally owned at-sea processing value would increase by 25 percent (with increases in BSAI values and GOA values), and associated labor income and FTEs both increasing by 25 percent. (In this region under baseline conditions, in-region processing accounts for about seven-tenths of the combined processing total value of sales and regionally owned at-sea processing accounts for about three-tenths of the total; labor income follows a similar pattern, but FTE employment is somewhat more heavily weighted toward the at-sea

sector.) The value of extra-regional deliveries by regionally owned catcher vessels would increase by 22 percent, while in-region deliveries would decrease by a less than significant amount. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 22 and 23 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would about the same. For this region, catcher vessel FTE employment far outpaces processing related employment, but payments to labor for processing still outpace those for catcher vessels. Processing labor income figures for this region should be treated with caution, however, as the model tends to overstate actual payments due to the relative proportion of high value species processed. The total regional direct, indirect, and induced labor income and associated FTEs would all increase (from a base of $34 million in labor income and 879 FTEs), but these changes would not rise to the level of significance. FMP 2.2 would have generally beneficial impacts on the southeast Alaska region, and these impacts would be significant for some local sectors, regional level impacts resulting from this FMP are unlikely to be significant given the diversity of the local economies and the relative lack of dependence on the groundfish fishery.

Washington inland waters. Total in-region groundfish processing value changes are negligible on a regional basis due to low baseline values and small changes from the baseline. Associated labor income and FTE jobs would increase by large percentages, but their overall low value render these changes not significant. Regionally owned at-sea processing value would increase by 22 percent (with increases in both BSAI and GOA values, although GOA values are comparatively very small), and associated labor income and FTEs would increase by 22 and 23 percent, respectively. The value of extra-regional and in-region deliveries by regionally owned catcher vessels would increase by 24 and 21 percent, respectively. Catcher vessel payments to labor and FTE jobs associated with extra-regional deliveries would increase by about 24 and 23 percent, respectively. For in-region deliveries, catcher vessel payments to labor and FTEs would increase by about 21 and 29 percent, respectively. In this region, processing dominates the regional labor income and FTE employment totals when compared to analogous catcher vessel figures, but it is important to note that catcher vessel totals are still far higher for this region than for any other. The total regional direct, indirect, and induced labor income would increase by about 22 percent and FTE employment would increase, but by a less than significant amount (from a base of $557 million in labor income and 10,316 FTEs). FMP 2.2 would result in significantly beneficial impacts to local sectors in the Washington inland waters region, but these impacts would not rise to the level of significance on a regional or a community of Seattle basis, given the scale of the local economy and the relative lack of dependency on the groundfish fishery.

Oregon coast. Total in-region groundfish processing value changes are zero, along with associated labor income and FTE jobs, as there is no activity under baseline conditions or under this FMP. Similarly, there are no regionally owned at-sea processors under baseline conditions or foreseen under this FMP, so all processing values, labor income, and FTE job values are zero. The value of extra-regional deliveries by regionally owned catcher vessels would increase by 22 percent, and associated labor income and FTE jobs would increase 22 and 28 percent, respectively. There is no in-region activity by catcher vessels owned in this region, so all values for product, labor income, and FTE jobs are zero under both baseline conditions and this FMP. The total regional direct, indirect, and induced labor income would increase by about 22 percent and FTE employment would increase by about 24 percent (from a base of $15 million in labor income and 318 FTEs). FMP 2.2 would result in significantly beneficial impacts to the local catcher vessel sector in the Oregon coast region, but these impacts would not be significant on a community or regional basis, given the scale and diversity of local economies and the low degree of dependency on the groundfish fishery.

Cumulative Effects of FMP 2.2

See Table 4.6-6 for a summary of the cumulative effects on regions and communities under FMP 2.1 and FMP 2.2.

In-Region Processing and Related Effects

- **Direct/Indirect Effects.** For FMP 2.2, direct/indirect effects are considered significantly beneficial for the Alaska Peninsula/Aleutian Islands and southcentral Alaska regions. Direct/indirect effects are generally insignificant for the Kodiak Island, southeast Alaska, Washington inland waters, and Oregon coast regions. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.2, cumulative effects fall between FMP 2.1 and FMP 1. Within the four Alaska regions, benefits from increased processing are offset by the adverse external effects in other fisheries, economic development and state and municipal revenue. For the Washington inland waters and Oregon coast regions, direct/indirect effects are insignificant, and there are no reasonably foreseeable events that would have a significant contribution. Cumulative effects for all six regions are cumulatively insignificant.

Regionally Owned At-Sea Processors

- **Direct/Indirect Effects.** For FMP 2.2, direct/indirect effects are considered significantly beneficial for the Kodiak Island, southcentral Alaska, southeast Alaska, and Washington inland waters regions. Direct/indirect effects are generally insignificant for the Alaska Peninsula/Aleutian Islands and Oregon coast regions. See the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and to a lesser extent, trends in state and municipal revenue. For more detail, see the analysis for in-region processing, FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. For more detail, see the analysis for In-region processing, FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.2, direct/indirect effects are beneficial for four regions and insignificant for the other two regions. Based on direct/indirect benefits and economic diversity, adverse external factors in Alaska regions are offset, and cumulative effects are insignificant.

Extra-regional Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects.** Under FMP 2.2, direct and indirect effects are significantly beneficial for the Washington inland waters, Kodiak Island, southeast Alaska, and Oregon coast regions and insignificant for southcentral Alaska and Alaska Peninsula/ Aleutian Islands. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. Catcher vessels are affected by changes that have occurred in the groundfish industry related to allocation and AFA sideboards, and by their participation in multi-species fisheries, particularly salmon, crab, and halibut. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all FMPs; for more detail see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.2, cumulative effects are insignificant for all regions, where direct/indirect benefits generally offset adverse external factors in Alaska regions. In southeast Alaska, direct/indirect effects are insignificant, and adverse external effects are likely to result in adverse but insignificant cumulative effects.

In-Region Deliveries of Regionally Owned Catcher Vessels

- **Direct/Indirect Effects.** Under FMP 2.2, direct/indirect effects are significantly beneficial for southcentral Alaska and Washington inland waters and are insignificant for the Alaska Peninsula/Aleutian Islands, Kodiak Island, southeast Alaska, and Oregon coast regions. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities, other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all FMPs; for more detail see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.2, direct/indirect effects of in-region deliveries range from beneficial to insignificant. However, given the size and diversity of some regional economies, and

the adverse nature of external effects related to other fisheries and revenue sharing in the Alaska regions that offset benefits, cumulative effects are insignificant for all regions.

Total Direct, Indirect, and Induced Labor Income and FTEs

- **Direct/Indirect Effects.** Under FMP 2.2, direct/indirect effects on labor income and employment increase and are significantly beneficial for Alaska Peninsula/Aleutian Islands, southcentral Alaska, Washington inland waters, and Oregon coast regions. In Kodiak Island and southeast Alaska the increase is insignificant. Refer to the previous section for a more detailed discussion of direct/indirect effects.

- **Persistent Past Effects.** The persistent past effects include trends and developments in fisheries, trends in state and municipal revenue, and public infrastructure and facility projects. Fishing is a major component of income and employment in many small Alaskan coastal communities. Federal, state, and local revenue has funded public infrastructure and facility projects that generate income and employment in many regions and communities. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects that are external to the proposed action include other state and federal fisheries, other economic development activities. other sources of municipal and state revenue, and effects of long-term climate change and regime shifts. These effects are the same for all indicators of effect for all FMPs. For more detail, see the discussion of persistent past effects under In-region processing in FMP 1, Section 4.5.9.2.

- **Cumulative Effects.** Under FMP 2.2, employment increases in all regions, but not necessarily in a significant manner. Within southcentral Alaska, Washington inland waters, and Oregon coast regions, fisheries are a small part of the regional economies and effects are dwarfed by other trends. Trends in other fisheries (particularly salmon) and reductions on municipal revenue, decrease labor income and employment offset these benefits, particularly in the Alaska Peninsula/Aleutian Islands, Kodiak Island, and southeast Alaska regions. Cumulative effects are beneficial, but insignificant in all regions.

4.6.9.3 Community Development Quota Program

The predicted direct and indirect effects of the groundfish fishery under FMP 2.1 and FMP 2.2 are described below. The past/present effects on CDQ are described in Section 3.9 (Table 3.9-126) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicator used in this analysis is allocation of catch to CDQ groups. It should be noted that allocation reflects potential revenue to CDQ groups, and indirectly the potential funds that are available for approved economic development activities in CDQ communities.

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Community Development Quota Related Impacts Under FMP 2.1

Under FMP 2.1, the fishery would be returned to an open-access scenario, where many time/area closures, gear restrictions, and PSC restrictions are repealed. The Federally mandated effort limitation program

enacted under the American Fisheries Act, with its CDQ allocation for pollock, would remain in place, and the CDQ Program, mandated by the MSA, would be modified to allocate only a percentage of the BSAI TAC for pollock to the CDQ Program. All other effort limitation programs including, but not limited to, the multi-species CDQ groundfish program, would be repealed. The multi-species groundfish CDQ program has steadily grown in relative importance since its inception, and in 2000 it accounted for approximately one-tenth of all CDQ royalties. Due to the loss of revenue and other economic and employment opportunities under this FMP, repeal of the multi-species program would generate adverse impacts to CDQ groups. However, under FMP 2.1, the pollock fishery would expand substantially over baseline conditions, so it is assumed that the pollock CDQ program would proportionally expand with the rest of that fishery. In terms of net change, this expansion would offset the losses incurred as a result of the discontinuation of the multi-species program, but it is the case that losses and gains would not be evenly distributed among CDQ groups due to differential reliance on the various species under the overall CDQ program (and within the multi-species program in particular). As a result, the significance of direct/indirect effects are unknown.

Community Development Quota Related Impacts Under FMP 2.2

As noted above, under FMP 2.2, direct/indirect effects would be similar to FMP 1. The existing level of BSAI groundfish quota would continue to be apportioned under the CDQ program to the 65 eligible western Alaska communities through the established CDQ groups. It is assumed that the multi-species CDQ program and quotas would continue as well. Under FMP 2.2, TAC increases, so no adverse impacts to the CDQ program or regions are anticipated.

Cumulative Effects of FMP 2.1 and FMP 2.2

Cumulative effects on CDQ for FMP 2.1 and FMP 2.2 are summarized on Table 4.6-6.

CDQ Allocations

- **Direct/Indirect Effects.** Under FMP 2.1, the direct/indirect effects of the groundfish fisheries on the CDQ program are unknown. Under FMP 2.2, the direct/indirect effects of the groundfish fisheries on the CDQ program are insignificant.

- **Persistent Past Effects.** The past/present effects on the CDQ program for groundfish fisheries include establishment of CDQ program; FMP amendments that further added or defined CDQ in 1992, 1995, 1996, and 1998; establishment of multi-species CDQ programs, and persistent limitations on economic development and associated employment activities. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities, other sources of municipal and state revenue all have the potential to affect the CDQ program adversely or beneficially. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 2.1, the potential cumulative effects for the CDQ program are unknown. There is some level of adverse cumulative effects to the CDQ program but significance is unknown. Under this FMP the fishery would be returned to an open access scenario creating increased competition. The multi-species CDQ groundfish program would be repealed, and the

overall groundfish CDQ program would be scaled back to only a single species, pollock. Discontinuation of the multi-species program would be an adverse impact, but given the increase in pollock TAC under this FMP, the CDQ return on pollock is expected to increase resulting in a beneficial impact. However, the losses and gains would not be evenly distributed among CDQ groups due to the differential reliance on various species. Under FMP 2.2, the cumulative effect on the CDQ program is insignificant. With guaranteed CDQ shares through the CDQ program, no significantly adverse cumulative impacts to the CDQ program are expected.

4.6.9.4 Subsistence

The predicted direct and indirect effects of the groundfish fishery under FMP 2.1 and FMP 2.2 are described below. The past/present effects on subsistence are described in 3.9 (including a summary in Table 3.9-126) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicators used in this analysis are other fisheries such as foreign JV, domestic, and state-managed fisheries, other economic development activities, sport and personal use, and long-term climate change and regime shift.

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Potential impacts to subsistence fall into four main categories: subsistence use of groundfish, subsistence use of Steller sea lions, subsistence use of salmon in western Alaska and bycatch in the groundfish fisheries, and indirect impacts on other subsistence activities, including loss of income that would be otherwise directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would be otherwise be available for joint production opportunities.

Under FMP 2.1, increases in the commercial fishery are anticipated but would not result in significantly adverse direct/indirect impacts to baseline subsistence groundfish fishing conditions. This FMP would have a conditionally significant adverse impact on Steller sea lion subsistence activities or take over baseline conditions. Although Steller sea lion protection measures are retained, questions remain about the impact of reduced pelagic forage availability as noted in earlier sections. If these issues result in significant Steller population decline, a significantly adverse impact to Steller sea lion subsistence activities could result. Under this FMP bookend, salmon bycatch may be expected to increase due to the repeal of PSC restrictions. This would create a conditionally significant adverse impact on subsistence salmon fisheries, with the conditions for significance being met if the resulting level of increased bycatch results in significant decreases in salmon returns to subsistence fishery areas. Catcher vessel activity and labor income are anticipated to increase under this FMP; therefore no adverse indirect impacts to subsistence through a decline in income or joint production opportunities are expected to occur.

Under FMP 2.2, no changes in the commercial fishery are anticipated that would result in impacts to baseline subsistence groundfish fishing conditions. There is also no indication that this FMP would have an adverse impact on Steller sea lion subsistence activities or take over baseline conditions. (Although under this FMP a more aggressive harvest policy is implemented, Steller sea lion protection measures are retained so it is assumed there are no adverse impacts to that species, but there are still concerns with pelagic forage availability as noted earlier). Salmon bycatch would essentially remain the same as under baseline conditions and is determined to have no significantly adverse effect on the return of salmon to western Alaska rivers; therefore no significantly adverse impacts to subsistence salmon fisheries are expected to result. Catcher

vessel activity and labor income are anticipated to increase under this FMP; therefore no adverse indirect impacts to subsistence through a decline in income or joint production opportunities are expected to occur.

Cumulative Effects of FMP 2.1 and FMP 2.2

The predicted direct and indirect effects of the groundfish fishery under FMP 2.1 and FMP 2.2 are described above. The past/present effects on subsistence are described in Section 3.9. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. Representative indicators used in this analysis are the same as those used in the direct/indirect analysis and include subsistence use of groundfish, subsistence use of Steller sea lions, subsistence use of salmon, and indirect impacts on other subsistence activities (Table 4.6-6). For a summary of the direct/indirect and cumulative ratings see Table 4.6-6.

Subsistence Use of Groundfish

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, no changes in the commercial fishery are anticipated that would result in impacts to baseline subsistence groundfish fishing conditions. The effects of FMPs 2.1 and 2.2 are insignificant.

- **Persistent Past Effects.** Foreign JV, domestic, and state-managed fisheries have decreased populations of some species of groundfish used for subsistence. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Other fisheries and long-term climate change have a potential to adversely contribute to subsistence use of the groundfish fisheries. Economic development and sport and personal use are not likely to adversely contribute to subsistence use of the groundfish fisheries. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 2.1 and FMP 2.2, the cumulative effects for subsistence use of groundfish are insignificant. The external impacts of other fisheries, economic development activities, and sport and personal use of groundfish are not likely to contribute to significantly adverse cumulative effects on the groundfish fisheries. Other state-managed fisheries could have adverse impacts to the subsistence use of groundfish due to the direct competition for the same species, but are not considered to be significant. The long-term climate change could adversely affect groundfish stocks.

Subsistence use of Steller Sea Lions

- **Direct/Indirect Effects.** Under FMP 2.1, there would be a conditionally significant adverse impact on Steller sea lion subsistence activities or take compared to baseline conditions. Although Steller sea lion protection measures are retained, questions remain about the impact of reduced pelagic forage availability as noted in earlier sections. If these issues result in significant Steller population decline, a significantly adverse impact to Steller sea lion subsistence activities could result. Under FMP 2.2, effects would be similar to FMP 1 and there would be insignificant effects on Steller sea lion subsistence activities or take over baseline conditions.

- **Persistent Past Effects.** The past/present effects on subsistence use of Steller sea lions include the following: a long-term decline in population of Steller sea lions due to a number of factors; a long-term decline in relative importance of marine mammals in local diets; commercial groundfish fishing taking prey species utilized by Steller sea lions; and Steller sea lion protection measures designed to assist in population recovery instituted in 2000. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, economic development, and long-term climate change have a potential to adversely contribute to Steller sea lions subsistence activities. Sport and personal use is not likely to adversely contribute to subsistence use of Steller sea lions. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMPs 2.1, a conditionally significant adverse cumulative effect is identified for subsistence use of Steller sea lions. The adverse cumulative effects on subsistence use of Steller sea lions all reduce the availability of Steller sea lions for subsistence use. They include the combined take for subsistence in other fisheries and in the groundfish fisheries and the reduced availability resulting from the continuing endangered status and long-term decline in abundance. Under FMP 2.2, the cumulative effect for subsistence use of Steller sea lions is insignificant. The adverse cumulative effects are not sufficient to significantly impact subsistence.

Subsistence Use of Western Alaskan Salmon and Bycatch in the Groundfish Fishery

- **Direct/Indirect Effects.** Under FMP 2.1, salmon bycatch may be expected to increase due to the repeal of prohibited species catch restrictions. This would create a conditionally significant adverse impact on subsistence salmon fisheries, with the conditions for significance being met if the resulting level of increased bycatch results in significant decreases in salmon returns to subsistence fishery areas. Under FMP 2.2, salmon bycatch would essentially remain the same as under baseline conditions and is determined to have insignificant effects.

- **Persistent Past Effects.** The past/present effects on subsistence use of salmon include the following: utilization for subsistence since pre-contact times; and Area M closures implemented to decrease intercept of salmon; these factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities and long-term climate change and regime shift could all adversely contribute to salmon subsistence activities. Sport and personal use is not likely to adversely contribute to salmon subsistence activities. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 2.1, a conditionally significant adverse cumulative effect is identified for subsistence use of salmon. Given the removal of the prohibited species catch caps, poor stock status of salmon runs in western Alaska and the combined effects of groundfish and state fisheries bycatch potential in BSAI and GOA, the availability of depressed salmon stocks for subsistence could be significantly impacted. Under FMP 2.2, insignificant cumulative effects are identified as the conditions are not expected to change from FMP 1.

Indirect Impacts on Other Subsistence Activities (Income and Joint Production Opportunities)

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, catcher vessel activity and labor income are anticipated to be neutral or increase,; therefore insignificant effects to subsistence through a decline in income or joint production opportunities are expected to occur.

- **Persistent Past Effects.** The past/present effects on the indirect impacts on other subsistence activities include joint production as a part of local groundfish and other commercial fishery development from the outset; and income from fishing used for investment in subsistence is similar to use of income from other activities. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities, and long-term climate change and regime shift could all adversely or beneficially contribute to indirect subsistence activities. Sport and personal use is not likely to adversely contribute to indirect impacts on other subsistence activities. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 2.1 and FMP 2.2, an insignificant cumulative effect is identified for indirect subsistence use. Under FMP 2.1 the increased opportunities for joint production are beneficial but not significant, offset by trends in other fisheries such as salmon. Under FMP 2.2 adverse cumulative effects are similar to the baseline and are not enough to have significant impacts on subsistence. Income catcher vessel activity, and joint production opportunities are not expected to be effected adversely. However, the external impacts of other fisheries, other economic development activities, and long-term climate change and regime shift could potentially contribute adversely to the indirect subsistence use.

4.6.9.5 Environmental Justice

The predicted direct and indirect effects of the groundfish fishery under Alternative 2 (FMP 2.1 and FMP 2.2) are described below. The past/present effects on Environmental Justice are described in Section 3.9 (and are summarized in Table 3.9-126) and below. This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The external effects used in this analysis are other fisheries such as foreign, JV, domestic, and state-managed fisheries, other economic development activities, other sources of municipal and state revenue, and long-term climate change and regime shift.

Direct/Indirect Effects of FMP 2.1

Potential impacts that drive Environmental Justice issues include employment/municipal revenue and taxes in communities with significant percentages of special populations (Alaska Native and minority processing workforce); revenue to Alaska Native-owned catcher vessels; revenue to Alaska Native-owned catcher processors; subsistence activities associated with groundfish, Steller sea lion, and salmon; and the loss of income from fishing that would be otherwise directed toward subsistence pursuits and the loss of access to commercial fishing vessels and gear that would otherwise be available for joint production opportunities. The regions that could experience potential impacts include the Alaska Peninsula and Aleutian Islands,

Kodiak Island, southcentral Alaska, southeast Alaska, Washington inland waters, Oregon coast, the CDQ regions, and western Alaska communities that harvest salmon for subsistence purposes.

Alaska Peninsula and Aleutian Islands. As described in existing conditions, this region encompasses a number of groundfish fishing communities, of which a number have predominantly Alaska Native populations. Also as described under existing conditions, the in-region processing workforce is predominantly a minority population. In-region processing employment would increase over baseline conditions by about 2,194 jobs; therefore, insignificant environmental justice impacts would result. Total in-region groundfish processing value would increase from $464 million to $758 million. Increased in-region processing value would correspond to additional municipal revenue and taxes to the local communities and therefore no associated environmental justice impacts would occur. In this region the ownership and crews of the catcher vessels are assumed to tend to mirror the demographic composition of populations of the home port communities, so local fleets from at least a few communities in this region are likely to be owned and crewed by Alaska Native residents. Under FMP 2.1, the total value of catcher vessel operations would increase as would corresponding labor income and employment; therefore, no associated Environmental Justice impacts would result.

Kodiak Island. As described in existing conditions, groundfish processing and catcher vessel activity in this region is highly concentrated in the City of Kodiak. Although the city is ethnically diverse, it does not have a predominantly Alaska Native population as do some of the groundfish fishing communities in the Alaska Peninsula/Aleutian Islands region. However, as described under existing conditions, the in-region processing workforce is predominantly a minority population. In-region processing employment would increase over baseline conditions by about 324 jobs; therefore, insignificant Environmental Justice impacts would result. Total in-region groundfish processing value would increase from $81 million to $127 million. Increased in-region processing value would correspond to additional municipal revenue and taxes to the City and the Kodiak Island Borough, but given local and regional demographics, this change is not likely to be relevant as an Environmental Justice issue. Ownership and crews of the catcher vessels are assumed to tend to mirror the demographic composition of populations of the City of Kodiak itself, and therefore the local fleet associated population is not likely to be predominantly Alaska Native (or comprised of other identified minority populations). Under FMP 2.1, the total value of catcher vessel operations would increase as would corresponding labor income and employment, but given demographic assumptions, this is unlikely to be connected to Environmental Justice issues.

Southcentral Alaska. As described in existing conditions, Environmental Justice concerns are much less salient in this region than in the Alaska Peninsula/Aleutian Islands or Kodiak Island regions. The communities most directly engaged in the groundfish fishery, particularly with respect to the processing sector, are largely non-Native communities, and have relatively large populations and diversified economic opportunities. Further, there is a relatively low level of groundfish related processing employment overall. Catcher vessel related employment is assumed to mirror community demographics, and thus it is unlikely that environmental justice issues will be associated with any employment change. In general, under FMP 2.1 overall combined direct, indirect, and induced labor income and FTEs increase, but this change is not linked to environmental justice concerns. Similarly, processing value increases, as do catcher vessel associated values, but these changes are not tied to Environmental Justice concerns. The direct/indirect effects on environmental justice are therefore, insignificant.

Southeast Alaska. The situation in this region is similar to that seen in southcentral Alaska, with the possible exception of the community of Yakutat, which is more predominantly Alaska Native than the other regionally

important groundfish communities. Data confidentiality constraints preclude a discussion of Yakutat alone, but otherwise overall environmental justice concerns appear not to apply in this region. In general, under FMP 2.1 overall combined direct, indirect, and induced labor income and FTEs increase, but this change is not linked to Environmental Justice concerns. Similarly, processing value increases and analogous catcher vessel associated values increase, but this change is not associated with environmental justice concerns. The direct/indirect effects on Environmental Justice are therefore, insignificant.

Washington inland waters. The greater Seattle area is the regional community most engaged in the groundfish fishery, and it is a demographically and economically diverse major metropolitan area. In-region processing does not occur, and while a number of other communities in the region outside of Seattle are home to groundfish catcher vessels, there is no indication that these communities or the associated vessel owners and crew are comprised of minority populations. As described in existing conditions, Environmental Justice concerns for this region are concentrated in the at-sea processing sector, due to the predominance of minority representation within this workforce. Under FMP 2.1, at-sea processing labor income increases by 43 percent and FTEs increase by 49 percent, so there are insignificant Environmental Justice impacts associated with this change.

Oregon coast. This region is engaged in the commercial groundfish fishery through its regionally owned catcher vessel fleet. This fleet is concentrated in a limited number of communities in the region, and there is no indication that these are minority communities, nor is there any indication that the population directly associated with fleet ownership and/or crew is either a minority population or a low-income population. In general, under FMP 2.1 overall combined direct, indirect, and induced labor income and FTEs increase, as do catcher vessel related values, but these changes are not linked to Environmental Justice concerns. The direct/indirect effects on Environmental Justice are therefore, insignificant.

CDQ region. The CDQ region is predominantly comprised of Alaska Native communities that have relatively limited commercial economic opportunities, so any adverse impacts to this program and region are likely to involve Environmental Justice concerns. As described in Section 4.6.9.3, the CDQ program and region would experience adverse impacts under FMP 2.1 from the elimination of the multi-species CDQ program. However, while these decreases would be offset by increases in returns from the pollock CDQ allocation for an overall net gain, this offset will not be uniform across CDQ groups.

Subsistence. Subsistence activities typically disproportionately involve Alaska Native communities and populations, and in a few cases (such as Steller sea lion subsistence) exclusively involve Alaska Native individuals and groups. As a result, adverse impacts to subsistence pursuits are likely to involve Environmental Justice concerns. Subsistence activities where there are potential Environmental Justice issues under FMP 2.1 include the harvest of Steller sea lion (primarily and activity in the Alaska Peninsula/Aleutian Islands region), and salmon (primarily an issue in western Alaska, where poor runs have adversely affected subsistence harvests). Increased TAC and reduction in or elimination of measures to limit salmon by-catch would potentially create significantly adverse Environment Justice issues for communities in the Alaska Peninsula/Aleutian Islands region that harvest Steller Sea lions, and in western Alaska communities that rely on salmon.

Under FMP 2.1, increased opportunities related to income and joint production indicate that there are insignificant impacts on Environmental Justice issues.

Cumulative Effects of FMP 2.1

The predicted direct and indirect effects of the groundfish fishery under FMP 2.1 are described above. The past/present effects on Environmental Justice Issues are described in Section 3.9. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. The representative indicators used in this analysis are the same as those used in the direct/indirect analysis.

- **Direct/Indirect Effects.** Under this FMP, direct/indirect impacts are insignificant as no changes in the commercial fishery are anticipated that would result in significantly adverse impacts to baseline. However, conditionally significant adverse effects on western Alaskan communities due to increased salmon bycatch under FMP 2.1 are possible.

- **Persistent Past Effects.** Persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities, other sources of municipal/state revenue, and long-term climate change and regime shift have the potential to adversely or beneficially affect Environmental Justice issues. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 2.1, an insignificant cumulative effect is identified for Environmental Justice, with the exception of a conditionally significant adverse effect on salmon subsistence in western Alaska. In general, benefits, including municipal revenues, would increase for both Alaska Native and non-Native communities participating in groundfish fisheries, but overall cumulative effects are insignificant. Increased joint production opportunities for subsistence are beneficial effects, but are cumulatively insignificant. The multi-species groundfish CDQ program would be eliminated under FMP 2.1, creating some level of adverse cumulative effects, but these effects would be largely offset by increased returns under the pollock CDQ program. Under FMP 2.1 salmon bycatch could be expected to increase due to the repeal of prohibited species catch restrictions. This could create conditionally significant adverse cumulative effects to subsistence fishery areas. Adverse cumulative effects to Steller sea lion subsistence activities could result but are not expected to be significant.

Direct/Indirect Effects of FMP 2.2

Alaska Peninsula and Aleutian Islands. As described in existing conditions, this region encompasses a number of groundfish fishing communities, of which a number have predominantly Alaska Native populations. Also as described under existing conditions, the in-region processing workforce is predominantly a minority population. In-region processing employment would increase over baseline conditions by about 827 jobs; therefore, no environmental justice associated impacts would result. Total in-region groundfish processing value would increase from $464 million to $575 million. Increased in-region processing value would correspond to additional municipal revenue and taxes to the local communities and therefore no associated environmental justice impacts would occur. In this region the ownership and crews of the catcher vessels are assumed to tend to mirror the demographic composition of populations of the home port communities, so local fleets from at least a few communities in this region are likely to be owned and

crewed by Alaska Native residents. Under FMP 2.2, the total value of catcher vessel operations would decrease as would corresponding labor income and employment; therefore, an apparent Environmental Justice impact may occur, but it is likely that this apparent decline is at least in part an artifact of the output model's limitation on the ability to adequately assign western Gulf of Alaska catch to the region rather than an actual decline.

Kodiak Island. As described in existing conditions, groundfish processing and catcher vessel activity in this region is highly concentrated in the City of Kodiak. Although the city is ethnically diverse, it does not have a predominantly Alaska Native population as do some of the groundfish fishing communities in the Alaska Peninsula/Aleutian Islands region. However, as described under existing conditions, the in-region processing workforce is predominantly a minority population. In-region processing employment would decrease over baseline conditions by about 37 jobs; therefore, no environmental justice impacts would result. Total in-region groundfish processing value would increase from $81 million to $86 million. The increased in-region processing value would provide higher municipal revenue and taxes to the City and the Kodiak Island Borough, and given local and regional demographics, this is not likely to be an Environmental Justice issue. Ownership and crews of the catcher vessels are assumed to tend to mirror the demographic composition of populations of the City of Kodiak itself, and therefore the local fleet associated population is not likely to be predominantly Alaska Native (or comprised of other identified minority populations). Under FMP 2.2, the total value of catcher vessel operations would increase as would corresponding labor income and employment, but given demographic assumptions, this is unlikely to be relevant as an Environmental Justice issue.

Southcentral Alaska. As described in existing conditions, environmental justice concerns are much less salient in this region than in the Alaska Peninsula/Aleutian Islands or Kodiak Island regions. The communities most directly engaged in the groundfish fishery, particularly with respect to the processing sector, are largely non-Native communities, and have relatively large populations and diversified economic opportunities. Further, there is a relatively low level of groundfish related processing employment overall. Catcher vessel related employment is assumed to mirror community demographics, and thus it is unlikely that Environmental Justice issues will be associated with any employment change. In general, under FMP 2.2 overall combined direct, indirect, and induced labor income and FTEs increase, but this change is not linked to environmental justice concerns. Similarly, processing value increases and catcher vessel associated values increase, but these changes are not tied to Environmental Justice concerns. See Table 3.9-126 for a summary of the direct/indirect effects on environmental justice in the southcentral Alaska region and communities.

Southeast Alaska. The situation in this region is similar to that seen in southcentral Alaska, with the possible exception of the community of Yakutat, which is more predominantly Alaska Native than the other regionally important groundfish communities. Data confidentiality constraints preclude a discussion of Yakutat alone, but otherwise overall Environmental Justice concerns appear not to apply in this region. In general, under FMP 2.2 overall combined direct, indirect, and induced labor income and FTEs increase, but this change is not linked to Environmental Justice concerns. Similarly, processing value decreases, but this change is not associated with Environmental Justice concerns.

Washington inland waters. The greater Seattle area is the regional community most engaged in the groundfish fishery, and it is a demographically and economically diverse major metropolitan area. In-region processing does not occur, and while a number of other communities in the region outside of Seattle are home to groundfish catcher vessels, there is no indication that these communities or the associated vessel

owners and crew are comprised of minority populations. As described in existing conditions, Environmental Justice concerns for this region are concentrated in the at-sea processing sector, due to the predominance of minority representation within this workforce. Under FMP 2.2, at-sea processing labor income and FTEs increase by 22 and 23 percent, respectively, so there are no Environmental Justice impacts associated with this change.

Oregon coast. This region is engaged in the commercial groundfish fishery through its regionally owned catcher vessel fleet. This fleet is concentrated in a limited number of communities in the region, and there is no indication that these are minority communities, nor is there any indication that the population directly associated with fleet ownership and/or crew is either a minority population or a low-income population. In general, under FMP 2.2 overall combined direct, indirect, and induced labor income and FTEs increase, as do catcher vessel related values, but these changes are not considered relevant to Environmental Justice concerns.

CDQ region. The CDQ region is predominantly comprised of Alaska Native communities that have relatively limited commercial economic opportunities, so any adverse impacts to this program and region are likely to involve Environmental Justice concerns. As described in Section 4.6.9.3, the CDQ program and region would experience impacts under FMP 2.2 similar to those seen under FMP 1, with no significantly adverse impacts foreseen.

Subsistence. Subsistence activities typically disproportionately involve Alaska Native communities and populations, and in a few cases (such as Steller sea lion subsistence) exclusively involve Alaska Native individuals and groups. As a result, adverse impacts to subsistence pursuits are likely to involve Environmental Justice concerns. As described above, adverse impacts to subsistence activities are not foreseen under FMP 2.2 (with the possible exception to Steller sea lion population dynamics), therefore no associated Environmental Justice impacts are anticipated.

Cumulative Effects of FMP 2.2

The predicted direct and indirect effects of the groundfish fishery under FMP 2.2 are described above. The past/present effects on Environmental Justice Issues are described in Section 3.9. This section will assess the potential for these effects to interact with other reasonably foreseeable future events and activities in the cumulative case. The representative indicators used in this analysis is the same as that used in the direct/indirect analysis (Table 4.6-6).

- **Direct/Indirect Effects.** Under this FMP, direct/indirect impacts range from beneficial to adverse, but any changes in the commercial fishery would result in insignificant effects to baseline, with the exception of conditionally significant adverse effects on western Alaskan communities due to increased salmon bycatch under FMP 2.2. However, the overall effects are still insignificant.

- **Persistent Past Effects.** Persistent past effects include trends and developments in fisheries, and trends in state and municipal revenue. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Other fisheries, other economic development activities, other sources of municipal/state revenue, and long-term climate change and regime shift

have the potential to adversely or beneficially affect Environmental Justice issues. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 2.2, an insignificant cumulative effect is identified for Environmental Justice. In general, benefits, including municipal revenues, would increase for both Alaska Native and non-Native communities participating in groundfish fisheries, but cumulative effects are insignificant. Increased joint production opportunities for subsistence are beneficial effects, but are cumulatively insignificant. Salmon bycatch could have adverse cumulative effects but not enough to be significant. Significantly adverse cumulative effects to Steller sea lion subsistence activities could result but not enough to be significant.

4.6.9.6 Market Channels and Benefits to U.S. Consumers

The predicted direct and indirect effects of the groundfish fishery under the FMP 2.1 and FMP 2.2 are described below. The past/present effects on Market Channels and Benefits to U.S. Consumers are described in Section 3.9 and below (Table 3.9-127). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. Representative indicators used in this analysis include product quantity, product year-round availability, product quality, and product diversity on Market Channels and Benefits to U.S. Consumers activities.

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

FMP 2.1 is expected to have an insignificant effect on benefits to U.S. consumers of groundfish products relative to the comparative baseline. FMP 2.1 will result in the increased production of most groundfish products. An estimate of the final market value of BSAI and GOA seafood products is not available; however, it would be substantially greater than $2.2 billion, the projected 5-year mean of the wholesale product value of BSAI and GOA groundfish after primary processing under FMP 2.1. This product value mean is 57 percent greater than the comparative baseline. While most products produced from Alaska groundfish enter an international market, some of the consumer benefits of this increased production are expected to accrue to American seafood consumers. The price elasticity of demand for groundfish products is fairly high in the U.S. market, but assuming that the demand for groundfish products is not perfectly elastic, the expected increase in production could result in lower prices and a gain of consumer surplus (i.e., net benefits) to the American public. The magnitude of that gain will depend on price elasticities that are not quantifiable at this time and on the degree to which production is shifted toward or away from export markets. However, it is unlikely that the gain in consumer surplus will be significant. Moreover, these potential consumer benefits may be partially offset by the expected decrease in quality of some groundfish products that results from the intensification of the race for fish occurring under this FMP.

FMP 2.2 is expected to have an insignificant effect on benefits to U.S. consumers of groundfish products relative to the comparative baseline. Under FMP 2.2 the BSAI and GOA groundfish fisheries are expected to continue to provide high and relatively stable levels of seafood products to domestic and foreign markets. An estimate of the final market value of BSAI and GOA seafood products is not available; however, it would be substantially greater than $1.7 billion, the projected 5-year mean of the wholesale product value of BSAI and GOA groundfish after primary processing under FMP 2.2. This product value mean is 26 percent greater than the comparative baseline. While most products produced from Alaska groundfish enter an international market, some of the consumer benefits of this increased production are expected to accrue to American seafood consumers. The price elasticity of demand for groundfish products is fairly high in the U.S. market,

but assuming that the demand for groundfish products is not perfectly elastic, the expected increase in production could result in lower prices and a gain of consumer surplus (i.e., net benefits) to the American public. However, it is unlikely that the gain in consumer surplus will be significant.

Cumulative Effects of FMP 2.1 and FMP 2.2

For a summary of the direct/indirect and cumulative ratings see Table 4.6-6.

Market Channels and Benefits to U.S. consumers

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2, increases in benefits to U.S. consumers of groundfish products are expected to occur but are insignificant.

- **Persistent Past Effects.** These effects on benefits to U.S. consumers of groundfish products include: Alaska Seafood Marketing Institute product promotion activities, research and public awareness regarding the health benefits of seafood consumption, aquaculture development increasing overall availability and demand for seafood products, and changes in processing technology increasing seafood quality.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable effects include other fisheries (supply of product) and long-term climate change and regime shift. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under FMP 2.1 and FMP 2.2, an insignificant cumulative effect is identified for benefits to U.S. consumers of groundfish products. FMP 2.1 will result in the increased production of most groundfish products with the potential decrease in quality of some groundfish products. FMP 2.2 will result in an expected increase in production with the potential to result in lower prices and a gain of consumer surplus. However, it is unlikely that the gain in consumer surplus will be significant. The external impacts of other fisheries have the potential to contribute adversely or beneficially to the U.S. consumers of groundfish products and the groundfish market channels. However, the wholesale groundfish product value in conjunction with products from other fisheries is not expected to change benefits to U.S. consumers. The long-term climate change and regime shift could adversely effect availability for market channels due to the natural fluctuations in groundfish stocks.

4.6.9.7 The Value of the Bering Sea and Gulf of Alaska Marine Ecosystems (Including Non-Consumptive and Non-Use Benefits)

The predicted direct and indirect effects of the groundfish fishery under FMP 2.1 and FMP 2.2 are described below. Benefits derived from marine ecosystems and associated species are used as a surrogate to evaluate non-consumptive and non-use benefits. The past/present effects on non-consumptive and non-use Benefits to U.S. general public are described in Section 3.9 and below (Table 3.9-127). This section will assess the potential for these effects to interact with other reasonably foreseeable future events in the cumulative case. The representative indicator used in this analysis is benefits the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits).

Direct/Indirect Effects of FMP 2.1 and FMP 2.2

Under FMP 2.1, the Bering Sea and GOA marine ecosystems and species associated with them are expected to generate significantly lower levels of some benefits relative to the comparative baseline. These findings are based on the assessment of the direct and indirect effects of FMP 2.1 on the environment with respect to the ecosystem issues of predator-prey relationships, energy flow and balance, and diversity. This assessment of ecosystem effects is presented in Section 4.6.10 of the Draft Programmatic SEIS.

As described in Section 3.9.7, the Bering Sea and GOA marine ecosystems and species associated with them provide a broad range of benefits to the American public. Some of the goods and services these ecosystems produce are not exchanged in normal market transactions but have value nonetheless. While there are difficulties in estimating the value the public places on protecting ecological conditions, Section 3.9.7 provides a qualitative discussion of possible benefits provided by the Bering Sea and GOA marine ecosystems. In addition to supporting commercial fisheries, these ecosystems support an array of recreational fishing and subsistence activities as well as non-consumptive activities such as wildlife viewing. Furthermore, some people may not directly interact with the Bering Sea and GOA marine ecosystems and the various species associated with them but derive satisfaction from knowing that the structure and function of these ecosystems are protected.

The focus in this analysis is on the direct and indirect effects of the alternatives on ecosystem benefits other than those that accrue to members of society who make a living harvesting, processing and distributing BSAI and GOA groundfish products or who purchase and consume these products. The direct and indirect effects of the alternatives on firms and communities that derive value from the commercial harvest and processing of groundfish are described elsewhere in the Draft Programmatic SEIS. Similarly, the effects of the alternatives on consumers of groundfish products are discussed in a separate section of the Draft Programmatic SEIS.

The value people assign to those marine ecosystem benefits that are unrelated to commercial groundfish fisheries are thought to be considerable. For example, the value of protecting the Steller sea lion alone may be substantial. As discussed in Section 3.9.7, a contingent valuation study suggests that there is a significant willingness to pay on the part of the American public for an expanded Federal Steller sea lion recovery program. At this time, however, there is insufficient information to provide a comprehensive measure of the benefits derived from these ecosystems and the various species associated with them.

A primary outcome of this FMP bookend is a large increase in the harvest levels that occur in most groundfish fisheries relative to the comparative baseline. In addition, time/area closures, gear restrictions, and bycatch restrictions would be repealed. As discussed in Section 4.6.10, the increase in harvest levels and elimination of measures are expected to have significantly or conditionally significant adverse consequences for predator-prey relationships, energy flow and balance, and diversity. In turn, these adverse effects on the Bering Sea and GOA marine ecosystems and associated species are expected to lead to a significant reduction in the levels of some of the benefits these ecosystems and species provide.

FMP 2.2 resembles FMP 2.1 in that it also represents a more aggressive harvest strategy. While some of the current measures that reduce the potential adverse effects of fishing on the Bering Sea and GOA marine ecosystems and species associated with them would remain in place under FMP 2.2, the increased harvest levels that occur under this FMP are predicted to have a significantly or conditionally significant adverse impact on predator-prey relationships for some marine mammals (Section 4.6.10). Consequently, the levels

of some of the benefits these marine ecosystems and species provide may be lower than the comparative baseline. The significance of this effect is conditional, as both the intensity of the effect and the probability of its occurrence are uncertain.

Cumulative Effects of FMP 2.1 and FMP 2.2

For a summary of the direct/indirect and cumulative ratings see Table 4.6-6.

Benefits derived from Marine Ecosystems and Associated Species

- **Direct/Indirect Effects.** Under FMP 2.1 and FMP 2.2 the risks of adverse effects that the Alaska groundfish fishery could have on marine ecosystems are increased. FMP 2.1 represents a more aggressive harvest strategy, as does FMP 2.2 but to a lesser extent. This is predicted to have a conditionally significant adverse impact on the levels of some of the benefits these ecosystems and associated species generate.

- **Persistent Past Effects.** Persistent past effects on non-consumptive and non-use benefits) include: an increase in public awareness of marine ecosystems; increased participation in recreational fishing and eco-tourism activities; and public perceptions with regard to fisheries management. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Reasonably Foreseeable Future External Effects.** Reasonably foreseeable future effects include other fisheries, and long-term climate change and regime shifts. These factors do not vary among alternatives; for more detail see the analysis in FMP 1.

- **Cumulative Effects.** Under both FMP 2.1 and FMP 2.2, a conditionally significant adverse cumulative effect is identified for benefits to the public derives from marine ecosystems and associated species (including non-consumptive and non-use benefits). The external effects of other fisheries have the potential to contribute adversely to benefits the public derives from marine ecosystems and associated species. FMP 2.1 and FMP 2.2 management measures could accelerate the introduction of non-native species, effect a change in pelagic forage availability, spacial and temporal concentration of fishery impact on forage, removal of top predators (potential for seabird bycatch and subsistence harvests of marine mammals), could increase the risk of changes in species, functional, and structural habitat diversity for the ecosystem. Long-term climate changes and regime shifts, in combination with fisheries-related pressures, could adversely affect species diversity due to the natural fluctuations in groundfish stocks. The greater fishing effort under FMP 2.1 could incrementally contribute to energy removal and energy redirection occurring on the groundfish fisheries.

4.6.10 Ecosystem Alternative 2 Analysis

Ecosystems are populations (consisting of single species) and communities (consisting of two or more species) of interacting organisms and their physical environment that form a functional unit with a characteristic trophic structure (food web) and material cycles (movement of mass and energy among the groups). The following analyses of potential direct/indirect and cumulative effects of Alternative 2 apply to the BSAI and GOA ecosystems. Where available information allows, each ecosystem is addressed separately.

In most cases, however, information is insufficient to allow individual consideration, and the two ecosystems are treated as a single entity.

As explained in Section 4.5.10, the analyses include numerous indicators representing potential direct, indirect, and cumulative effects of the alternative and specific bookends where applicable. Significance thresholds for the effect categories are presented in Table 4.1-7.

Direct/Indirect Effects FMP 2.1 and FMP2.2 – Ecosystems

Change in Pelagic Forage Availability

Pelagic forage availability is assessed by evaluating population trends in pelagic forage biomass for species with age-structured population models. Trends in bycatch of other forage species (herring, squid, and forage species group) in the groundfish fisheries are a measure of the potential impact on those groups in the BSAI and GOA (Figures H.4-19 and H.4-20 of Appendix H). Table 4.5-81 summarizes the average values from 2003-2008 for these measures and the percent change in the average values from the baseline amounts.

In FMP 2.1, pelagic forage biomass in the BSAI (Bering Sea walleye pollock and Aleutian Islands Atka mackerel) would decline by about 17 percent but would still be high relative to historical levels in the assessment. In the GOA, pelagic forage biomass (specifically, walleye pollock) shows an average increase of about 38 percent from the baseline. Twenty-year biomass projections show similar trends. Bycatch of other forage species almost triples in the BSAI and increases about 45 percent in the GOA. The absolute amount of bycatch in each region is relatively small (4,890 mt and 380 mt, respectively). Estimates of forage biomass from food web models of the EBS indicate that this bycatch is probably a small proportion of the total forage biomass (Aydin *et al.* 2002). However, lack of population-level assessments for some species in the forage species group means that corresponding species-level effects are unknown. If a target fishery were to develop for forage species such as capelin, there is a potential for the combined effects of fishing to affect predators such as seabirds, which leads to a conditionally significant adverse impact of this FMP on seabirds. However, the amount of forage needed by predators is uncertain.

In FMP 2.2, pelagic forage biomass in the BSAI (Bering Sea walleye pollock + Aleutian Islands Atka mackerel) would decline by about 13 percent. Pelagic forage biomass (specifically, walleye pollock) in the GOA shows an average increase of about 53 percent from the baseline. Twenty-year biomass projections show similar trends. Bycatch of other forage species more than doubles in the BSAI and decreases by about 25 percent in the GOA. The absolute amount of bycatch in each region is relatively small (3,500 mt and 190 mt, respectively). As concluded in FMP 2.1, estimates of forage biomass from food web models of the EBS indicate that this bycatch is probably a small proportion of the total forage biomass (Aydin *et al.* 2002). However, lack of population-level assessments for some species in the forage species group means that corresponding species-level effects are unknown.

Because target species that rely on these forage species for prey are not brought below their MSSTs by these changes, FMP 2.1 and FMP 2.2 are determined to have insignificant effects on the BSAI and GOA target species with respect to pelagic forage availability (Table 4.1-7). The amount of prey needed for Steller sea lions and the importance of adult pollock to northern fur seals have not been determined. The predicted changes in prey for FMP 2.1 and FMP 2.2 may have significantly adverse and conditionally significant adverse effects relative to the baseline for these marine mammals. Sections 4.6.1 through 4.6.8 discuss effects of pelagic forage abundance on other resource categories.

Spatial and Temporal Concentration of Fishery Impact on Forage

Spatial and temporal concentration of fishery impacts on forage species is assessed qualitatively by considering the potential for the alternatives to concentrate fishing on forage species in regions utilized by predators that are tied to land, such as pinnipeds and breeding seabirds. Additionally, possibility for concentration of fishing effort to result in an ESA listing or lack of recovery to an ESA-listed species is considered. FMP 2.1 would continue the existing closures around Steller sea lion rookeries, repeal the ban on forage fish, and open areas previously closed to trawling (except Steller sea lion closures), but still retain the spatial/temporal allocation of TAC for pollock and Atka mackerel. Because this FMP retains Steller sea lion closures, it should not result in space/time concentrations of fisheries removals that would impair the long-term viability of Steller sea lions. If a fishery were to be initiated on the forage species group, there is potential for this to result in removals large enough to impact breeding seabird populations that rely on these smaller forage species. However, the level of removals resulting in significant population-level effects on seabirds is unknown. Bering Sea pollock fisheries have shown increasing catch in northern fur seal foraging habitat, but more research is required to determine if the amounts of pollock removed are having a population-level effect. Therefore, FMP 2.1 is considered to have a conditionally significant adverse effect on the ecosystem with regard to spatial/temporal concentration of fisheries on forage species. FMP 2.2 would continue all the existing closures, including those around Steller sea lion rookeries, and would retain the spatial/temporal allocation of TAC for pollock and Atka mackerel. This FMP is judged to have an insignificant effect on the ecosystem with regard to spatial/temporal concentration of fisheries on forage species.

Removal of Top Predators

Removal of top predators, either through directed fishing or bycatch, is assessed by evaluating the trophic level of the catch relative to trophic level of the groundfish biomass (Figures H.4-21 through H.4-24 of Appendix H), bycatch levels of sensitive top predator species such as birds and sharks (Figures H.4-25 and H.4-26 of Appendix H), and a qualitative evaluation of the potential for catch levels to cause one or more top-level predator species to fall below biologically acceptable limits (minimum stock size threshold for groundfish, lead to ESA listing or prevent recovery of an ESA-listed species). Trophic level of the catch in both the BSAI and GOA is a very stable property, changing less than 3 percent on average from the baseline, and trophic level of the groundfish species for which we have age-structured models, changes less than one percent on average. Under FMP 2.1, top-predator bycatch amounts would increase by an average of about 53 percent relative to the baseline in the BSAI and about 40 percent over the baseline in the GOA. The absolute values of average catch for these species are estimated to be 1,032 mt and 1,840 mt in the respective regions under this FMP (Table 4.5-81). FMP 2.2 would result in top-predator bycatch amounts increasing about 16 percent in the BSAI and decreasing an average of 12 percent in the GOA relative to the baseline. Average catch of these species in the BSAI and GOA is estimated to be 782 mt and 1,150 mt, respectively (Table 4.5-81).

Increased fishing effort and the retention of former seabird protection measures under FMP 2.1 are considered conditionally significant adverse measures for ESA-listed seabirds such as short-tailed albatross. Also, removal of area closures around the Pribilof Islands may lead to disproportionate take of fulmars from that colony. Thus, FMP 2.1 may have a conditionally significant adverse impact on seabird top predators. FMP 2.1 and FMP 2.2would not further impair the recovery of whale species through direct takes. Sections 4.6.7 and 4.6.8 discuss the effects of groundfish fishery direct takes on specific seabird and marine mammal populations. The effect of shark bycatch on shark populations is unknown at present, and research directed

at better assessing population levels of these sensitive (late maturing, low fecundity, low natural mortality) species is needed to better assess the potential effects from groundfish fisheries. Section 4.6.3 contains further information on sharks. Stability in trophic level of the catch is indicative of minimal effect of the fishery on target and PWS species top predators (Greenland turbot, arrowtooth flounder, sablefish, Pacific cod, and Pacific halibut). See Section 4.6.1 for details on these target species and Section 4.6.2 for Pacific halibut. Overall, FMP 2.1and 2.2 would have insignificant effects on whales, pinnipeds, top-predator target, and PSC species and unknown effects on top predators such as sharks. FMP 2.1 may result in conditionally significant adverse effects on seabirds. However, because seabird bycatch levels in FMP 2.2 are expected to be similar to the baseline, FMP 2.2. is determined to have an insignificant effect on seabird population status.

Introduction of Non-Native Species

The introduction of non-native species through ballast water exchange and hull-fouling organism release from fishing vessels could potentially disrupt Alaskan marine food web structure (Fay 2002). There have been 24 species of non-indigenous species of plants and animals documented primarily in shallow-water marine and estuarine ecosystems of Alaska, with 15 species recorded in PWS. It is possible that most of these introductions were from tankers or other large commercial vessels that have large amounts of ballast exchange. However, exchange via fishery vessels that take on ballast from areas where invasive species have already been established and then transit through Alaskan inshore waters has been identified as a threat in a recently developed State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002). Consequently, this effect is evaluated as conditionally significant adverse in the baseline.

Total groundfish catch levels are used as an indicator of potential changes in the amount of these releases via groundfish fishery vessels (Figures H.4-27 and H.4-28 of Appendix H, Table 4.5-82). Total catch would increase by about 42 percent in the BSAI and 69 percent in the GOA under FMP 2.1, relative to the baseline. These catch levels are at the upper end of catches previously observed in these areas, indicating an increased potential for fishing vessel introduction of non-native species through ballast water exchange or release of hull-fouling organisms. Because there is insufficient information regarding fishing effort levels that would result in a successful introduction, this potential effect is evaluated as conditionally significant adverse with respect to predator-prey relationships. Under FMP 2.2, total catch would increase by about 17 percent in the BSAI and 14 percent in the GOA. These catch levels are similar to recent catches in these areas. Therefore, the potential direct/indirect effects of FMP 2.2 on predator-prey relationships through the introduction of non-native species are evaluated as insignificant.

Energy Flow and Balance

As discussed in Section 3.10, fishing may alter the amount and flow of energy in an ecosystem by removing energy and altering energetic pathways through the return of discards and fish processing offal back into the sea. The recipients, locations, and forms of this returned biomass may differ from those in an unfished system. Baseline energy removals, in the form of total retained catch, were less than one percent of the total system energy determined by mass-balance modeling of the system and were determined to have an insignificant impact on the ecosystem. FMP 2.1 retained-catch removals (Table 4.5-81), which change about 35 percent and 79 percent from the baseline in the BSAI and GOA, respectively, are large changes relative to the baseline. Therefore, potential impacts of FMP 2.1 on energy removals are determined to be conditionally significant adverse with respect to the potential for producing changes in system biomass, respiration, production, or energy cycling outside the range of natural variability (Table 4.1-7). FMP 2.2

retained-catch removals (Table 4.5-81) change 17 and 20 percent from the baseline in the BSAI and GOA, respectively, and are still less than one percent of the total system energy as determined from mass-balance modeling in the EBS. Impacts of FMP 2.2 on energy removals are determined to be insignificant.

Energy re-direction, in the form of discards or fishery offal production or unobserved gear-related mortality, can potentially change the natural pathways of energy flow in the system. Animals damaged when passing through the meshes of trawls may later die and be consumed by scavengers. Bottom trawls can expose benthic organisms and make them more vulnerable to predation. Discards and offal production can cause local enrichment and changes in species composition or water quality if discards or offal returns are concentrated there. Estimates of total discards (Table 4.5-81, Figures H.4-29 and H.4-30 of Appendix H) under FMP 2.1 more than doubled for the BSAI and increase approximately 36 percent for the GOA relative to the baseline. Because these amounts are large deviations from baseline conditions, they create potential for a conditionally significant adverse effect on ecosystem-level energy cycling characteristics. Trends in total discards in FMP 2.2 show a more than 16 percent increase in the BSAI and a 4 percent decrease in the GOA. These amounts are still less than one percent of the unused detritus already going to the bottom, as estimated from mass-balance modeling of the EBS. Therefore, FMP 2.2 would have an insignificant effect on ecosystem-level energy cycling characteristics.

Change in Species Diversity

Fishing can alter different measures of diversity. Species-level diversity, or the number of species, can be altered if fishing essentially removes a species from the system. Fishing can alter functional diversity from a trophic standpoint if it selectively removes or depletes a trophic guild member and thus changes the way biomass is distributed within a trophic guild. Functional diversity from a structural habitat standpoint can be altered if fishing methods such as bottom trawling remove or deplete organisms such as corals, sea anemones, or sponges that provide structural habitat for other species. Fishing can alter genetic diversity by selectively removing faster-growing fish or removing spawning aggregations that might have genetic characteristics that are different from other spawning aggregations. Larger, older fishes may be more heterozygous (i.e., have more genetic differences or diversity), and some stock structures may have a genetic component (see review in Jennings and Kaiser 1998). Consequently, one would expect a decline in genetic diversity to result from heavy exploitation of a fishery.

Significance thresholds for effects of fishing on species diversity are catch removals high enough to cause the biomass of one or more species (target or non-target) to fall below, or to be kept from recovering from levels already below MSST for target species, or to result in ESA listing for non-target species (Table 4.1-7). Indicators of significance are population levels of target and non-target species relative to MSST or ESA listing thresholds, linked to fishing removals. Bycatch amounts of sensitive (low population turnover rates) groups that lack population estimates (skates, sharks, grenadiers, and sessile invertebrates, such as corals, inhabiting Habitat Areas of Particular Concern, or HAPC) may also indicate potential for fishing impact on these species (Table 4.5-82, Figures H.4-31 and H.4-32 of Appendix H). Closed areas also provide protection, particularly to less-mobile species like HAPC biota, so the amount of area closures across habitat types can indicate the degree of species-level diversity protection. Baseline determinations were made of insignificance for most of these indicators, and unknown for skates and sharks.

Under FMP 2.1, the only closures would be those required under Steller sea lion protection measures. Bycatch of HAPC biota would increase by about 8 percent in the BSAI and stay about the same in the GOA (Table 4.5-81). However, the bycatch model does not take into account the different bycatch rates that might

occur due to opening of previously closed areas, and thus HAPC bycatch amounts could increase by an unknown amount. Furthermore, Steller sea lion closures are closer inshore relative to the distribution of some of the most sensitive HAPC biota, corals, and closures may not provide protection against species-level extinction for this group. FMP 2.1 may have conditionally significant adverse effects on HAPC biota. The increased fishing effort and use of former seabird protection measures in this FMP increase the likelihood for ESA listing or for preventing recovery of ESA-listed seabirds such as the short-tailed albatross. The levels of seabird bycatch that would result from FMP 2.1 are unknown. Increased trawling and potential for trawl third-wire mortality increases relative to the baseline in this FMP and may have a conditionally significant adverse impact to seabird species diversity.

FMP 2.2 results in bycatch of HAPC biota increasing by about 28 percent in the BSAI and decreasing by about 3 percent in the GOA (Table 4.5-81). Area closures would most likely be sufficient to provide protection against species-level extinction for this group of sessile organisms, although more research on coral distributions is needed. Therefore, FMP 2.2 would have an insignificant effect on species diversity with respect to HAPC biota. Catch amounts of target species, prohibited species, seabirds, and marine mammals under this FMP would be insufficient to bring these species below minimum population thresholds and would have an insignificant effect on species diversity for these groups. It is unknown whether bycatch amounts of skates, sharks and grenadiers would be at levels high enough to bring species within these groups to minimum population thresholds. Further research on the species-level distribution, abundance trends, and life-history parameters of these species is necessary to assess potential population-level effects. Although forage species population levels are not known, their relatively high turnover rates would likely protect them from falling below minimum biologically acceptable limits. However, some of the species in this forage group are not well studied (e.g., stichaeids, gunnels), and life-history parameter determination should be a priority for future research. Thus, FMP 2.2 would have insignificant and unknown effects on species diversity.

Catch amounts of prohibited species and marine mammals would be insufficient to bring these species below minimum population thresholds and thus are given an insignificant effect on these groups. Some target species would be depleted to levels below their MSST, a significantly adverse effect on species diversity. It is unknown whether bycatch amounts of skates, sharks, and grenadiers would be at levels high enough to bring species within these groups to minimum population thresholds, but these bycatch amounts would increase in FMP 2.1. Further research on the species-level distribution, abundance trends, and life history parameters of these species is necessary to assess the risk of falling below minimum population abundance thresholds. Although forage species population levels are not known, their relatively high turnover rates would likely protect them from falling below minimum biologically acceptable limits. However, some of the species in this forage group are not well studied (e.g., stichaeids, gunnels). Thus, FMP 2.1 would have insignificant (prohibited species, marine mammals, forage), significantly adverse (some target species), conditionally significant adverse (seabirds, HAPC biota), and unknown (skates, sharks, grenadiers) effects on species diversity. Catch amounts of target species, prohibited species, seabirds, and marine mammals under FMP 2.2 would be insufficient to bring these species below minimum population thresholds and would have an insignificant effect on species diversity for these groups. Potential effects of bycatch on skates, sharks, grenadiers and Other Species are unknown for FMP 2.2. More years of survey data and life-history parameter determination for skates, sharks, grenadiers, and Other Species may better define population trends and help determine whether further protection might be warranted. Sections 4.6.1 through 4.6.8 present detailed analyses of the potential for fishery removals to affect minimum population thresholds for each of these groups and thus ultimately to affect species diversity.

Change in Functional Diversity

Functional (either trophic or structural habitat) diversity can be altered through fishing if fishing selectively removes one member of a functional guild, which may result in increases in other guild members. A functional guild is a group of species that use resources within the ecosystem in similar ways. Significance thresholds are catch removals high enough to cause a change in functional diversity outside the range of natural variability observed for the system (Table 4.1-7). Indicators of the possible magnitude of effects include qualitative evaluation of guild or size diversity changes relative to fishery removals, bottom gear effort changes that would provide a measure of benthic guild disturbance, and bycatch amounts of HAPC biota, a structural habitat guild. In FMP 2.1, it is unknown to what degree changes in trophic guild diversity would result from increasing the catch removals of target species that are guild members. Because walleye pollock and Atka mackerel tend to be dominant members of their respective trophic guilds, fishing removals that cause these species to fall below their MSST would tend to increase trophic guild diversity measures because these species would be less dominant. Consequently, the potential effect of FMP 2.1 on trophic diversity is rated as conditionally significant adverse.

Under FMP 2.1, the possible increases in HAPC biota bycatch that could result from opening areas that were previously closed to bottom trawling have not been modeled. Members of the HAPC biota guild serve important functional roles, known only in a preliminary way, to provide fish and invertebrates with structural habitat and refuge from predation. The abundance of these structural species necessary to provide protection is not known, and it may be important to retain populations of these organisms that are well distributed spatially in order to fulfill their functional role. The long-lived nature of corals, in particular, makes them susceptible to permanent eradication in fished areas. Existing Steller sea lion trawl closures are spread throughout the Aleutian chain, which likely has some of the highest densities of coral in the region. However, the closures are in waters shallower than where corals tend to be found. Therefore, the increase in fishing pressure and types of areas closed to trawling in this FMP are not sufficient to provide additional protection beyond the baseline to these sensitive organisms and may result in a potentially adverse population-level change. Consequently, this FMP is evaluated as having a significantly adverse effect on structural habitat diversity.

Under FMP 2.2, the species composition and amounts of removals, bottom gear effort, and bycatch amounts of HAPC biota (Table 4.5-82, Figures H.4-31 and H.4-32 of Appendix H) are similar to baseline conditions, in which fishing impacts on functional guild diversity are determined as insignificant for trophic diversity and for structural habitat diversity. Due to similar trends reflecting baseline conditions, the potential direct/indirect effects of FMP 2.2 on functional diversity, both trophic characteristics and structural habitat, are evaluated as insignificant.

Change in Genetic Diversity

Genetic diversity can be affected by fishing through heavy exploitation of certain spawning aggregations or systematic targeting of older age classes that tend to have greater genetic diversity. Under FMP 2.1, some target species would fall below MSST, but because the spatial/temporal management of TAC in the fisheries would not change, the MSST threshold would not be reached as a result of fishing-related declines in genetic diversity. Thus, an insignificant impact of fishing on genetic diversity is expected for this FMP. However, baseline genetic diversity remains unknown for most species and the actual direct/indirect effects that fishing would have on genetic diversity under this FMP are also largely unknown.

Under FMP 2.2, no target species would fall below MSST, and spatial/temporal management of TAC, catch, and selectivity patterns would remain consistent with present conditions. Consequently, the effect of fishing on genetic diversity would be insignificant under FMP 2.2. However, baseline genetic diversity remains unknown for most species and the actual direct/indirect effects that fishing would have on genetic diversity under this FMP are also largely unknown.

Cumulative Effects FMP 2.1 – Ecosystems

The following sections discuss the potential cumulative effects of FMP 2.1 on the ecosystem, acting additively or interactively with the effects of external human actions and natural processes persisting from the past, existing in the present, and predicted for the reasonably foreseeable future. These potential cumulative effects are summarized in Table 4.5-82. Data and calculations supporting the cumulative energy removal analyses for all of the alternatives are presented in Table 4.5-81.

Change in Pelagic Forage Availability

- **Direct/Indirect Effects.** The direct/indirect effects of implementing FMP 2.1 are expected to be significantly adverse for prey species utilized by the Steller sea lion, and conditionally significant adverse for northern fur seal and seabird prey species. FMP 2.1 would have an insignificant effect on BSAI and GOA groundfish target species with respect to pelagic forage availability. For the Steller sea lion, northern fur seal, and seabirds, the projected fishery-induced changes in pelagic forage biomass may be outside the natural level of abundance or variability for prey species relative to predator demands (Table 4.1-7). However, these predator demands, with respect to both quantity and prey preferences, have not been accurately quantified, and the potential short- and long-term effects of this FMP on top predators cannot be predicted with a high degree of confidence.

- **Persistent Past Effects.** Past effects of forage fish bycatch by the BSAI pollock and GOA rockfish domestic fisheries, and targeted domestic catches of pollock and Atka mackerel are likely to have affected forage fish populations in ways that may persist into the present and future (Section 3.10.1.4). From about 1925 to 1941, Alaska herring harvests for oil and meal ranged from about 50,000 to 150,000 mt per year, and a large foreign herring fishery removed from about 30,000 to 150,000 mt per year during the 1960s and 1970s (ADF&G 2003a). Past climatic changes, including inter-decadal oscillations and ENSO events, have been shown to affect forage fish populations (Section 3.10.1.5), and these effects may persist.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska manages herring fisheries on a sustainable basis and has established a maximum exploitation rate (fraction of the spawning population removed by the fishery) of 20 percent. Fisheries are closed if stock size falls below MSST. Lower exploitation rates are applied when herring stocks decline to near-threshold levels (ADF&G 2003a). This management approach is expected to continue for the indefinite future. Subsistence harvests will continue to remove an increment of pelagic forage biomass each year. Relative to the BSAI and GOA groundfish fisheries, however, the additional contribution of subsistence fisheries to the annual removal of pelagic forage biomass is likely to be very small. The EVOS suggests that a large oil or fuel spill that coincides in space and time with herring or capelin spawning would most likely produce population declines, and other pelagic forage species (such as eulachon, which spawn on beaches) might also be adversely affected. Future climate change,

especially a regime shift, would likely affect the productivity, and therefore the population sizes, of pelagic forage species (Section 3.10.1.5).

- **Cumulative Effects.** Direct/indirect effects on pelagic forage availability as modeled under FMP 2.1 are rated as significantly adverse for Steller sea lion prey species and conditionally significant adverse for northern fur seal and seabird prey species. Any potentially adverse contribution by one or more external factors, including State of Alaska directed fishery removals and subsistence harvests of forage fishes such as herring, capelin, or eulachon, would add a small increment of forage fish removal to this significantly or conditionally significant effect without substantially increasing its magnitude. A large marine oil or fuel spill would have the potential to add substantially to the depletion of forage fish populations in combination with heightened fishing pressures under FMP 2.1, resulting in a significantly adverse cumulative effect.

Spatial/Temporal Concentration of Fishery Impact on Forage

- **Direct/Indirect Effects.** FMP 2.1 would have a conditionally significant adverse direct/indirect effect on the ecosystem with regard to spatial/temporal concentration of fisheries on forage species. Because this FMP retains Steller sea lion closures, it should not result in space/time concentrations of fisheries removals that would impair the long-term viability of sea lion subpopulations. Levels of forage fish removals sufficient to result in a population-level effect on seabirds are unknown, and there is uncertainty whether a large fishery on forage species would develop under FMP 2.1. Bering Sea pollock fisheries have shown increasing catch in northern fur seal foraging habitat in the baseline, and more research is required to evaluate whether the amounts of pollock removed are having a population-level effect on fur seals. The conditionally significant rating reflects the high degree of uncertainty and lack of data regarding (a) forage requirements of key top predator species and (b) the eventual levels of forage impact that FMP 2.1 fishing effort would produce.

- **Persistent Past Effects.** Geographic and seasonal concentrations of past forage fish bycatch from the BSAI pollock and GOA rockfish fisheries, herring bycatch, and targeted catches of pollock and Atka mackerel have affected forage fish populations in ways that may have persisted into the present and future (Section 3.10.1.4). Past herring fisheries have followed a stable pattern of timing and location dictated by the spawning behavior of the fish (ADF&G 2003a). Past climatic changes, including inter-decadal oscillations and ENSO events, have shown effects on recruitment rates and distribution patterns of forage fish populations (Section 3.10.1.5). Such conditions may be exerting a persistent effect on forage fish populations, although evidence is not sufficient to allow quantification.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska directed herring fishery will exert fishing pressures on herring and other forage fish populations at particular times and places that could overlap with fishing pressures from the groundfish fisheries. Because the herring fishery occur mainly inshore, overlap with the groundfish fishery is more likely temporal than spatial. Subsistence harvest patterns are not coordinated with commercial fishing effort and will sometimes overlap with spatial/temporal patterns of the groundfish fishery, but the incremental contribution of subsistence to this cumulative effect will continue to be negligible. The EVOS of 1989 suggests that a large oil or fuel spill that coincides in space and time with herring or capelin spawning would most likely produce population declines and adversely impact other pelagic forage species (such as eulachon, which spawn on beaches). Finally, future climate change, especially a regime shift, could

alter the spatial/temporal distributions of pelagic forage species in ways that are synergistic with spatial/temporal concentrations of fishing effort in the BSAI and GOA groundfish fisheries.

- **Cumulative Effects.** Under FMP 2.1, a conditionally significant adverse cumulative effect on pelagic forage availability could result in the reasonably foreseeable future, synergistic with the spatial/temporal concentration of the BSAI and/or GOA groundfish fishing effort. The conditions under which this effect could be significant relate to location and timing. If the fishing efforts of State of Alaska directed fisheries, principally for herring and subsistence fish harvests converge in space and time with a fuel or oil spill, forage fish populations could be depressed sufficiently to impair the long-term viability of ecologically important top predators such as seabirds and marine mammals (Table 4.1-7). Future climate change, consistent with effects observed in the recent past (Section 3.10.1.5), could alter the spatial/temporal distributions of pelagic forage species and reduce or intensify this potential cumulative effect.

Removal of Top Predators

- **Direct/Indirect Effects.** FMP 2.1 may have conditionally significant adverse effects on seabirds, insignificant effects on whales, pinnipeds, top-predator target species, and PSC species, and unknown effects on sharks. The greatest concern regarding the effects of FMP 2.1 on top predators is the increased potential for bycatch of seabirds. Increased fishing effort and the maintenance of former, rather than improved, seabird protection measures under FMP 2.1 are considered conditionally significant adverse measures for ESA-listed seabirds such as short-tailed albatross. Also, removal of area closures around the Pribilof Islands may lead to disproportionate takes of fulmars from that colony. The conditionally significant rating reflects uncertainty about future bycatch levels and existing population-level effects of bycatch removals on seabird species (Section 3.7).

- **Persistent Past Effects.** Before passage of the MSA in 1976, groundfish fisheries in the BSAI and GOA produced much higher than present bycatch levels of sharks, seabirds, and marine mammals. Historical whaling, resulting in high mortality levels in the 1960s (Section 3.10.1.3), produced a sustained effect on these slowly reproducing populations that is reflected in the low present-day abundance of whale species in the North Pacific. State of Alaska directed groundfish fisheries, which are small and sustainably regulated, have annually removed top predators such as sablefish and Pacific cod at levels safely above MSST (ADF&G 2003b). These fisheries also produced shark, seabird, and marine mammal bycatch in the past, although quantitative data are lacking on past and current bycatch levels in these fisheries. Past and present groundfish fisheries operating outside of U.S. jurisdiction in the western Bering Sea have also contributed to the bycatch of top predators, in some cases at high levels (Sections 3.7.1 and 3.10.1). Marine mammals continue to be removed for subsistence, although at much lower levels than in the past, but past harvests may have had a sustained effect on some populations that persist today. Finally, there is evidence that past climatic variability may have affected the recruitment and distribution of some top predator fish species (Section 3.10.1.5; Hollowed *et al.* 1998).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery will continue to remove a sustainable portion of the Pacific halibut population, a top predator. The current management plan is likely to continue in the reasonably foreseeable future, although a modified approach has been proposed to produce a yield similar to the present policy while reducing

variations in annual yield due to changes in stock abundance, assessment methods, and estimated removals by other fisheries (Clark and Hare 2003). High levels of seabird bycatch and resulting direct mortality are expected to continue annually from North Pacific Ocean longline fisheries operating outside of the EEZ. Available data and estimates for the annual incidental take of individual bird species by these external fisheries are provided and discussed in Sections 3.7.1-19. The State of Alaska directed groundfish fisheries, operating in state waters of the eastern GOA and southeast Alaska, Cook Inlet, PWS, Kodiak, and the Alaska Peninsula, and in all state waters for lingcod, sablefish, and Pacific cod, will continue to remove targeted top predatory fish species in small numbers relative to the domestic groundfish fisheries in Federal waters (ADF&G 2003b). Subsistence harvests of marine mammals will continue in the future with an increasing trend toward co-management by NOAA Fisheries and Alaska Native organizations. The Protected Resources Division of NOAA Fisheries will continue to develop management and conservation programs to ensure that annual subsistence harvests are sustainable (NOAA Fisheries 2003). A large fuel or oil spill at sea would result in direct mortality of marine mammals, with mortality levels depending on the location, size, and timing of the spill. Finally, a future climatic regime shift could alter total numbers of top predators in the BSAI and GOA ecosystems by increasing or limiting recruitment.

- **Cumulative Effects.** A conditionally significant adverse cumulative effect on total numbers of top predators could result from FMP 2.1 in combination with continued high levels of seabird bycatch by North Pacific Ocean longline fisheries operating outside the EEZ. Because these external fisheries are generally not managed in conjunction with the BSAI and GOA domestic groundfish fisheries, there is a likelihood that the present high levels of seabird bycatch will continue in the reasonably foreseeable future. The conditions under which this cumulative effect could be significant are the continuation of high external seabird bycatch rates in conjunction with a large fuel or oil spill, along with incremental removals of top predators by the IPHC longline fishery, State of Alaska directed groundfish fisheries, and subsistence harvests of marine mammals. As determined from recent climatic studies (Section 3.3), a climatic regime shift is probable in the reasonably foreseeable future, and this could intensify or reduce the potential effects by influencing recruitment.

Introduction of Non-Native Species

- **Direct/Indirect Effects.** FMP 2.1 could produce a conditionally significant adverse effect on predator-prey relationships through the introduction of non-native species to the BSAI and GOA ecosystems. The condition under which this potential adverse effect would become significant is the establishment of one or more viable exotic populations. This potential effect is rated conditionally significant because there is insufficient information about the relationship between fishing effort levels and the probability that an introduced exotic species would establish a viable population.

- **Persistent Past Effects.** For decades the annual arrival of groundfish fishing vessels from ports outside of Alaska has made it possible for non-native species to enter Alaskan waters through the release of ballast water and hull-fouling organisms. Commercial shipping has provided a similar means for the introduction of non-native species (Fay 2002). There have been 24 non-indigenous species of plants and animals documented in Alaskan waters, with 15 of these recorded in PWS, where most of the research has been conducted. Although oil tankers, through the release of ballast water, have been speculated to be the primary source for these introductions, cruise ships and fishing vessels coming from areas where invasive species have already been established have also been identified as a threat in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002).

From 1991 to 2001, 396,522 accidental escapes of Atlantic salmon were reported from British Columbia fish farms (ADF&G 2002a). Concerns have been expressed regarding the potential effects of introduced Atlantic salmon on native Pacific salmon populations, including diseases and parasites, colonization, interbreeding and hybridization, predation, habitat destruction, and competition, particularly in locations where depressed stocks of Pacific salmon species provide a potential niche for the Atlantic species (Brodeur and Busby 1998, ADF&G 2002a). In the past, Alaska's northern climate, geographic isolation, and small human population, among other factors, may have prevented the establishment of viable populations by non-native species introduced from more temperate regions (Fay 2002).

- **Reasonably Foreseeable Future External Effects.** IPHC longline fishery vessels, international longline and groundfish fleets operating outside the EEZ, and vessels participating in State of Alaska directed fisheries will continue to be potential sources of exotic introductions in the reasonably foreseeable future. In addition, commercial shipping, including cruise ships and barges and tankers with high-volume ballast water releases, will continue to bring non-native species into Alaskan waters on a recurring basis, maintaining a continuing pressure on indigenous populations (Fay 2002). Escapes and releases of farmed Atlantic salmon from Washington State and British Columbia net-pens might eventually establish runs in GOA coastal streams and rivers. Introduced pathogens and parasites associated with farmed Atlantic or Pacific salmon could infect wild stocks. A future regime shift or long-term warming trend could remove the protection that colder conditions may currently provide against exotic species, allowing viable non-native populations to become established.

- **Cumulative Effects.** When sources of exotic species external to the domestic groundfish industry are considered in combination with FMP 2.1, it is conceivable that viable populations could eventually become established in the BSAI and/or GOA, producing a conditionally significant adverse cumulative effect (Table 4.1-7). One possible, but unproven, condition for this outcome would be a future climatic regime shift or long-term warming trend that might allow exotic species currently limited by low seawater temperatures to establish viable populations in the BSAI and/or GOA.

Energy Removal

- **Direct/Indirect Effects.** The effects of FMP 2.1 on energy removal would be conditionally significant adverse. Because predicted catch levels are large changes relative to the baseline, FMP 2.1 is considered to have the potential for producing changes in system biomass, respiration, production, or energy cycling outside the range of natural variability (Table 4.1-7).

- **Persistent Past Effects.** The domestic groundfish fisheries, State of Alaska commercial fisheries, IPHC longline fisheries, commercial harvests of marine mammals, and subsistence harvests have all removed biomass from the BSAI and GOA ecosystems, either as targeted species or as bycatch, and these removals, in a regulated and mitigated form, continue today (Section 3.10). Aggregate biomass levels removed by unregulated past human activities would have been influenced by climatic effects on overall system productivity, with biomass removals increasing as productivity increased and decreasing with climate-related productivity declines.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fisheries, State of Alaska commercial fisheries, subsistence fish harvests, and subsistence marine mammal harvests will

continue to remove biomass from the BSAI and GOA ecosystems in the future. The incremental contribution of the combined State of Alaska herring and crab and IPHC halibut fisheries is estimated at about 4 percent of the cumulative biomass that would be removed annually under this FMP (Table 4.5-81). The State of Alaska directed groundfish and subsistence fisheries will remove an additional small increment annually (ADF&G 2003b, 2001). It should be noted that Russian and other fisheries operating in the western Bering Sea and in international waters of the central Bering Sea (doughnut hole) will also remove biomass in the future, but these regions show sufficient differences from the EBS with respect to production regimes and topographic and hydrographic features that are viewed as only partly comparable systems, and their interactive components with the EBS, where present, have not yet been characterized (Aydin *et al.* 2002).

- **Cumulative Effects.** The implementation of FMP 2.1 is predicted to have a conditionally significant adverse cumulative effect with respect to energy removal. If the annual total catches of the State of Alaska herring and crab and IPHC halibut fisheries in the reasonably foreseeable future are similar to the 1994-2002 averages, the combined total catch of these external fisheries will represent a 4.3 percent addition to the estimated total catch for the groundfish fisheries alone under this FMP (Table 4.5-81). It is unknown if this additional increment of biomass removal would intensify or make more probable the predicted direct/indirect effect of the groundfish fishery. Further study of fishery removals as energy debits and their resulting ecosystem-level characteristics is needed (Table 4.1-7).

Energy Redirection

- **Direct/Indirect Effects.** The direct/indirect effects of FMP 2.1 on energy redirection are evaluated as conditionally significant adverse. Because total discard biomass projections would result in large changes from baseline conditions under FMP 2.1, the potential for a conditionally significant adverse effect on ecosystem-level energy cycling characteristics exists (Table 4.1-7).

- **Persistent Past Effects.** Ecosystem energetics is a dynamic process and it is difficult to know whether past changes in energy cycling and pathways of energy flow in the BSAI and GOA produced effects that still persist. The most far-reaching changes in quantities and geographic patterns of bycatch discards and offal production from both fish and marine mammal harvests came with international agreements, legislation, and regulatory actions in the 1950s through the 1970s, culminating in passage of the MSA in 1976 (Section 3.10.1.3). These corrective actions greatly curtailed the destabilizing levels of energy redirection that reached their peak in the mid-twentieth century from commercial whaling, fur seal harvests, high-seas driftnet fisheries, and the international commercial groundfish and salmon fisheries that existed. It seems likely, therefore, that under current management practices, quantities and patterns of energy redirection in the BSAI and GOA are much more limited than 50 years ago.

- **Reasonably Foreseeable Future External Effects.** Quantities and geographic patterns of bycatch discards and fish processing wastes released into the sea from the IPHC and State of Alaska commercial fisheries and subsistence harvests are not expected to change substantially in the future. External energy will also enter the system as graywater and refuse released into the sea from commercial freighters, tankers, and cruise ships. Finally, future climatic trends have the potential to affect energy cycling in the ecosystem; in particular, a warming trend would be expected to accelerate rates of energy conversion, whereas cooler conditions would tend to have a retarding effect.

- **Cumulative Effects.** The implementation of FMP 2.1 is predicted to have a conditionally significant adverse effect on the ecosystem through energy redirection. The large increase in fishing effort that would occur under this FMP, in combination with external sources such as the IPHC halibut fishery, State of Alaska commercial fisheries, annual subsistence harvests of fish and marine mammals, and the release of graywater and refuse from commercial shipping, could create the potential for a cumulative effect that results in long-term changes outside the range of natural variability. At the local level, water quality degradation can be expected from the increased release of fish processing offal into low-energy environments, such as coves and bays, where nutrients from these wastes can concentrate in sheltered waters and alter local patterns of energy cycling. Although this is not an ecosystem-level effect, it is noted as a consequence of commercial fishing that will continue into the future and may increase under FMP 2.1. The discharge of offal from fish processing facilities and graywater and other refuse from marine vessels into Alaskan waters is regulated through EPA and ADEC permitting programs.

Change in Species Diversity

- **Direct/Indirect Effects.** Predicted effects of FMP 2.1 on species diversity are rated as significantly adverse for target species that would be reduced to levels below their MSSTs, conditionally significant adverse for HAPC biota because of uncertainty regarding the extent to which bycatch of these organisms would increase, conditionally significant adverse for seabirds because of increased fishing effort without a compensatory increase in seabird protection measures, insignificant for prohibited species, forage fish, and marine mammals, and unknown for skates, sharks, grenadiers, and Other Species.

- **Persistent Past Effects.** Although the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, the timing of various increases and decreases in species abundance of fish, seabirds, and marine mammals has not shown a consistent correlation with groundfish fishing intensity (Sections 3.10.1). With the notable exception of the Steller's sea cow extinction in the 1760s (Section 3.10.1.1), changes in species diversity have not characterized the BSAI and GOA ecosystems. Although no fishing-related species removals have been documented under fisheries management policies in effect during the past 30 years, elasmobranchs (sharks, skates, and rays) are particularly susceptible to removal, and benthic invertebrate (including HAPC) species are susceptible to bottom trawling (Section 3.10.3). Seabirds have been particularly vulnerable to bycatch mortality, leading to reduced populations of some bird species below minimum biologically acceptable limits. Lack of data on seabird population trends prevents analysis of past effects of fisheries management or environmental change on most seabird species (Section 3.7), but commercial fisheries have been implicated in some declines through bycatch potential. Livingston *et al.* (1999) found that long-term increases and decreases in the abundance of selected BSAI invertebrate, fish, bird, and marine mammal species did not show beneficial correlations with prey abundance, and that cyclic fluctuations in species abundance occurred in both fished and unfished species. As emphasized in Section 3.10.1.5, evidence is accumulating that physical oceanographic factors, particularly climate, have a controlling influence on biological community composition in the BSAI and GOA.

- **Reasonably Foreseeable Future External Effects.** Although past levels of seabird bycatch by the IPHC, western Bering Sea, and State of Alaska fisheries have not been thoroughly or consistently quantified, they are considered substantial and can be expected to continue in the future (Section 3.7). In addition, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, beluga whales, harbor seals), may deplete numbers to levels near or below biologically acceptable limits in the future. The potential for introduced exotic species to establish viable populations in the BSAI and GOA will also continue. Such exotics may include Atlantic salmon escapes from net-pen farms, invertebrates and plants introduced through ballast water and from ship hulls, and pathogens introduced by Pacific salmon species that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and make it easier for introduced exotics to establish viable populations.

- **Cumulative Effects.** Under FMP 2.1 , a significantly adverse effect on species diversity could result from seabird bycatch by the IPHC longline fishery, western Bering Sea fisheries, and State of Alaska commercial fisheries, in combination with the BSAI and GOA groundfish fisheries. In addition, one or more introduced exotic species may establish a viable population that would change species diversity in a adverse way by competing with native species for food and habitat (Fay 2002). The consistent, sustained concentration of harvest effort on particularly accessible subpopulations of marine mammals from year to year could intensify this potential effect. Finally, climate change has the potential to alter species productivity and distribution, and a long-term warming trend might facilitate the establishment of viable populations by one or more exotic species. Under some combination of these conditions, the biomass of one or more species could fall below minimum biologically acceptable limits (Table 4.1-7).

Change in Functional (Trophic) Diversity

- **Direct/Indirect Effects.** Potential effects on functional diversity in terms of trophic (nutrition-related) characteristics relate to changes in the variety of species within trophic guilds. Under FMP 2.1, the predicted effects of the groundfish fisheries on trophic diversity are rated as conditionally significant adverse. This rating reflects the potential for increased fishing effort to cause pollock and Atka mackerel to fall below their MSSTs, thereby making them less dominant members of their guild. Due to the inability to predict the level of diversity change that may result, this rating is conditional based on the ability of the effect to cause changes in functional diversity outside the range of natural variability observed for the system (Table 4.1-7).

- **Persistent Past Effects.** It is considered unlikely that past removals of fish by the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries significantly affected the variety of species within trophic guilds. Livingston *et al.* (1999) found no evidence that groundfish fisheries had caused declines in trophic guild diversity for the groups studied. They also found that past changes in species diversity within guilds related to increases in a dominant guild member (e.g., pollock, rock sole) rather than to decreases in abundance caused by fishing pressure (Section 3.10.3). Past variations in climate, such as ENSO events, interdecadal oscillations, and regime shifts, may have affected trophic diversity by influencing the productivity and distribution of different species in different ways, thereby altering the relative proportions of species within guilds. However, little research on this type of effect was conducted in the BSAI and GOA in past decades.

- **Reasonably Foreseeable Future External Effects.** NOAA Fisheries and ADF&G biologists have recently brought attention to the potential for escaped farmed Atlantic salmon to establish viable Alaskan populations in competition with one or more of the five Pacific salmon species and steelhead (Brodeur and Busby 1998, ADF&G 2002a, Fay 2002). In addition, the concentrated take of marine mammals from the same local subpopulations over a period of years could affect species diversity within piscivore guilds, that is, guilds consisting of fish-eating species. Releases of ballast water and hull-fouling organisms introduced to BSAI and GOA waters from fishing vessels and commercial shipping could also lead to the establishment of viable populations in competition with native species at similar trophic levels (Fay 2002). A climatic regime shift in the future could affect trophic diversity by forcing trends that expand some trophic levels and contract others, and a long-term warming trend could facilitate the establishment of relatively cold-intolerant exotic populations.

- **Cumulative Effects.** The implementation of FMP 2.1 could produce a conditionally significant adverse effect on trophic diversity. If the farming of Atlantic salmon along the Pacific coast continues or increases, there is a potential for escaped or released fish to establish one or more viable populations in the future, thus adding a new salmonid to the trophic structure. Other exotic species introduced through commercial shipping and fishing vessels also have the potential to establish viable populations, especially if facilitated by a favorable climatic change, thus altering trophic diversity. In addition, subsistence mammal harvests, particularly where individual subpopulations are placed under pressure, have the potential to affect species diversity within piscivore guilds, at least locally. None of these potential external effects is likely to be interactive or synergistic with the direct/indirect effects of FMP 2.1, because different trophic guilds would be affected, but an additive effect is possible.

Change in Functional (Structural Habitat) Diversity

- **Direct/Indirect Effects.** The issue of concern with respect to functional diversity in terms of structural habitat is the removal, by bottom gear, of HAPC biota such as corals, sea anemones, and other sessile invertebrates that provide physical structures for habitat by other species, including economically important groundfish species and their prey. Present (comparative baseline) trawl closures to protect the Steller's sea lion are spread throughout the Aleutian chain, but these closures are in waters shallower than where corals tend to be found. Because the areas that would be closed to trawling under FMP 2.1 would be similar to the comparative baseline conditions, they would not be sufficient to provide protection to these sensitive organisms. Therefore, the potential direct/indirect effects of FMP 2.1 on functional diversity are rated as significantly adverse.

- **Persistent Past Effects.** Bottom-trawling by the pre-MSA international groundfish fisheries, groundfish fisheries after passage of the MSA in 1976, and State of Alaska scallop fisheries have all contributed to the damage or depletion of the structural habitat functional guild in past years. Because little is known about the taxonomic structure of benthic communities of the BSAI and GOA, any past effects of trawling and other fishing-related activities on the species diversity of these communities cannot be quantified. Long-term climatic trends may also have influenced HAPC species through effects on their productivity and distribution, but in the absence of data no conclusions can be made.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska scallop fishery will employ bottom dredges that will continue to damage or remove structural habitat provided by sessile

invertebrates such as corals, sea anemones, and sponges. This effect is not likely to be reduced in the future. In addition, a large oil or fuel spill from commercial shipping could contact areas covered by these sensitive bottom-dwelling organisms and damage or kill them. A climatic regime shift could change the mean annual seawater temperature sufficiently to increase or retard the growth of benthic organisms, thereby altering structural habitat diversity.

- **Cumulative Effects.** The implementation of FMP 2.1 may produce a significantly adverse cumulative effect on structural habitat diversity by damaging or removing benthic HAPC biota, particularly coral. Direct/indirect effects of FMP 2.1 could be intensified under at least three conditions. First, the additive effect of the scallop fishery, which employs bottom dredges, could add to the effects of bottom trawling by the groundfish fisheries on HAPC biota. Second, a large petroleum spill could also damage these sensitive organisms. Third, a change in seawater temperature resulting from a climatic regime shift in the future could reduce the productivity (and thus population size, growth, and ability to recover from damage) as well as distribution of sensitive bottom-dwelling invertebrates that provide ecologically important structural habitat.

Change in Genetic Diversity

- **Direct/Indirect Effects.** If FMP 2.1 were implemented, no target species would fall below MSST, and spatial/temporal management of TAC, other catch, and selectivity patterns in the fisheries would be similar to present conditions. Fishing pressure would not focus on specific spawning aggregations or systematically target older age classes that tend to have greater genetic diversity. Therefore, effects of the groundfish fisheries on genetic diversity are expected to be insignificant under FMP 2.1. However, baseline genetic diversity remains unknown for most species and the actual effects that fishing would have on genetic diversity under this FMP are also largely unknown.

- **Persistent Past Effects.** The pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, but data are not available to indicate whether genetic diversity was measurably affected. As discussed in Section 3.10.3, if a fishery concentrates on certain spawning aggregations or on older (larger) age classes of a target species that tend to have greater genetic diversity (dating from an earlier period when fishing was less intensive), then genetic diversity will tend to decline in fished versus unfished systems. It is possible that genetic diversity has already declined in the BSAI and GOA ecosystems, but this cannot be known in the absence of data. Genetic assessments of North Pacific pollock populations and subpopulations conducted by Bailey *et al.* (1999) have found genetic variations among different stocks, but these studies have not found genetic variability across time within the same stocks that might indicate effects from commercial fishing. Heavy exploitation of certain spawning aggregations existed historically (e.g., Bogoslof pollock), but recent and current spatial/temporal management of groundfish has been designed to reduce fishing pressure on spawning aggregations.

- **Reasonably Foreseeable Future External Effects.** Several external factors have the potential to affect the genetic diversity of the BSAI and GOA ecosystems. Atlantic salmon escapes from coastal net-pen farms in Washington State and British Columbia could establish Alaskan runs and viable populations (ADF&G 2002a, Fay 2002). Subsistence harvests of fish could concentrate effort on the same specific subpopulations from year to year, inadvertently but selectively depleting genetically

distinct stocks. Similarly, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, beluga whales, harbor seals), may also deplete genetic diversity. The potential for introduced exotic invertebrates to establish viable populations in the BSAI and GOA will unavoidably continue with fishing vessel and commercial shipping traffic in the future. Such exotics may also include pathogens introduced by Pacific salmon that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and enable introduced exotics to establish viable populations.

- **Cumulative Effects.** The implementation of FMP 2.1 is predicted to have an insignificant cumulative effect on genetic diversity. Several external factors, such as Atlantic salmon escapes, subsistence harvests of marine mammals that concentrate on the same subpopulations year after year, exotic species introduced through commercial shipping traffic, and climatic facilitation of viable exotic populations, have the potential to produce changes in the genetic diversity of the BSAI and GOA ecosystems. However, none of these factors would directly involve the genetic diversity of species targeted or taken incidentally by the groundfish fisheries. For this reason, external sources of potential change in genetic diversity would not be additive or interactive with the groundfish fisheries in the future.

Cumulative Effects FMP 2.2 – Ecosystems

The following sections discuss the potential cumulative effects on the ecosystem of FMP 2.2, acting additively or interactively with the effects of external human actions and natural processes persisting from the past, occurring in the present, and predicted for the future. These potential cumulative effects are summarized in Table 4.5-82. Data and calculations supporting the cumulative energy removal analyses for all of the alternatives are presented in Table 4.5-81.

Change in Pelagic Forage Availability

- **Direct/Indirect Effects.** Under FMP 2.2, BSAI pelagic forage biomass, as estimated by Bering Sea pollock and Aleutian Islands Atka mackerel, is predicted to decrease relative to the comparative baseline. Total biomass of GOA pollock is predicted to increase during the same period (Table 4.5-81). Bycatch of other forage species would increase by more than 200 percent in the BSAI and decrease by about 25 percent in the GOA. Because target species that rely on these forage species for prey would not be brought below their MSSTs by these changes, FMP 2.2 is determined to have an insignificant effect on the BSAI and GOA ecosystems with respect to pelagic forage availability (Table 4.1-7). However, the quantities of prey needed by Steller sea lions and the importance of adult pollock to northern fur seals have not been determined. Consequently, the predicted changes in pelagic forage availability may have significantly adverse and conditionally significant adverse effects relative to the baseline for these marine mammals.

- **Persistent Past Effects.** Past effects of forage fish bycatch by the BSAI pollock and GOA rockfish domestic fisheries, and targeted domestic catches of pollock and Atka mackerel, are likely to have affected forage fish populations in ways that may persist into the present and future (Section 3.10.1.4). From about 1925 to 1941, Alaska herring harvests for oil and meal ranged from about 50,000 to 150,000 mt per year, and a large foreign herring fishery removed from about 30,000 to 150,000 mt per year during the 1960s and 1970s (ADF&G 2003a). Past climatic changes, including

inter-decadal oscillations and ENSO events, have been shown to affect forage fish populations (Section 3.10.1.5), and these effects may persist.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska manages herring fisheries on a sustainable basis and has established a maximum exploitation rate (fraction of the spawning population removed by the fishery) of 20 percent. Fisheries are closed if stock size falls below MSST. Lower exploitation rates are applied when herring stocks decline to near-threshold levels (ADF&G 2003a). This management approach is expected to continue for the indefinite future. Subsistence harvests will continue to remove an increment of pelagic forage biomass each year. Relative to the BSAI and GOA groundfish fisheries, however, the additional contribution of subsistence fisheries to the annual removal of pelagic forage biomass is likely to be very small. The EVOS suggests that a large oil or fuel spill that coincides in space and time with herring or capelin spawning would most likely produce population declines, and other pelagic forage species (such as eulachon, which spawn on beaches) might also be adversely affected. Finally, future climate change, especially a regime shift, would likely affect the productivity, and thereby the population sizes, of pelagic forage species (Section 3.10.1.5).

- **Cumulative Effects.** Direct/indirect effects on pelagic forage availability as modeled under FMP 2.2 are rated as significantly adverse for Steller sea lion prey species and conditionally significant adverse for northern fur seal. Any potentially adverse contribution by one or more external factors, including State of Alaska directed fishery removals and subsistence harvests of forage fishes such as herring, capelin, or eulachon, would add a small increment of forage fish removal to this significantly or conditionally significant effect without substantially increasing its magnitude. However, a large marine oil or fuel spill could have the potential to add substantially to the depletion of forage fish populations, resulting in a significantly adverse cumulative effect for the Steller sea lion and northern fur seal.

<u>Spatial/Temporal Concentration of Fishery Impact on Forage</u>

- **Direct/Indirect Effects.** FMP 2.2 would have an insignificant effect on the ecosystem with regard to spatial/temporal concentration of fisheries on forage species. It would not result in fishing concentrations on forage species high enough to impair the long-term viability of the Steller sea lion and other marine mammals or seabirds (Table 4.1-7).

- **Persistent Past Effects.** Geographic and seasonal concentrations of past forage fish bycatch from the BSAI pollock and GOA rockfish fisheries, herring bycatch, and targeted catches of pollock and Atka mackerel have affected forage fish populations in ways that may persist (Section 3.10.1.4). Past herring fisheries have followed a stable pattern of timing and location dictated by the spawning behavior of the fish (ADF&G 2003a). Past climatic changes, including inter-decadal oscillations and ENSO events, have shown effects on recruitment rates and distribution patterns of forage fish populations (Section 3.10.1.5). Such conditions may be exerting a persistent effect on forage fish populations, although evidence is not sufficient to allow quantification.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska directed herring fishery will exert fishing pressures on herring and other forage fish populations at particular times and places that could overlap with fishing pressures from the groundfish fisheries. Because the herring fishery occurs mainly inshore, overlap with the groundfish fishery will be temporal more than spatial.

Subsistence harvest patterns are not coordinated with commercial fishing effort and will sometimes overlap with spatial/temporal patterns of the groundfish fishery, but the incremental contribution of subsistence to this cumulative effect will continue to be negligible. The EVOS in 1989 suggests that a large oil or fuel spill coinciding in space and time with herring or capelin spawning will most likely produce population declines, and adverse impacts to other pelagic forage species (such as eulachon, which spawn on beaches). Finally, future climate change, especially a regime shift, could alter the spatial/temporal distributions of pelagic forage species in ways that might be synergistic with spatial/temporal concentrations of fishing effort in the BSAI and GOA groundfish fisheries.

- **Cumulative Effects.** Under FMP 2.2, a conditionally significant adverse cumulative effect on pelagic forage availability could result in the future, synergistic with the spatial/temporal concentration of the BSAI and/or GOA groundfish fishing effort. The conditions under which this effect could be significant relate to location and timing. If the fishing efforts of State of Alaska directed fisheries, principally for herring, and subsistence fish harvests converge in space and time with a fuel or oil spill, forage fish populations could be depressed sufficiently to impair the long-term viability of ecologically important top predators such as seabirds and marine mammals (Table 4.1-7). Future climate change, consistent with effects observed in the recent past (see Section 3.10.1.5), could alter the spatial/temporal distributions of pelagic forage species by reducing or intensifying this potential cumulative effect.

Removal of Top Predators

- **Direct/Indirect Effects.** FMP 2.2 would have insignificant effects on whales, pinnipeds, seabirds, top-predator target species, and PSC species in their function as top predators; and unknown effects on sharks as top predators. Trophic level of the catch, affecting top predators that are target species, would not change significantly from the baseline and would not result in any species near or below MSST. Top predator bycatch amounts would increase over the baseline in the BSAI and decrease in the GOA; these changes would not cause the biomass of one or more top predator species to fall below minimum biologically acceptable limits (Table 4.1-7).

- **Persistent Past Effects.** Before passage of the MSA in 1976, groundfish fisheries in the BSAI and GOA produced much higher than present bycatch levels of sharks, seabirds, and marine mammals. Historical whaling resulting in very high mortality levels in the 1960s (Section 3.10.1.3), produced a sustained effect on these slowly reproducing populations that is reflected in the low present-day abundance of whale species in the North Pacific (Section 4.5.11). State of Alaska directed groundfish fisheries, which are sustainably regulated, have annually removed top predators such as sablefish and Pacific cod at levels safely above MSST (ADF&G 2003b). These fisheries also produced shark, seabird, and marine mammal bycatch in the past, although quantitative data are lacking on past and current bycatch levels in these fisheries. Past and present groundfish fisheries operating outside of U.S. jurisdiction in the western Bering Sea have also contributed to the bycatch of top predators, in some cases at high levels (Sections 3.7.1 and 3.10.1). Marine mammals continue to be removed for subsistence, although at much lower levels than in the past, and past harvests may have sustained effects on some populations today (Section 3.10.1). Finally, there is evidence that past climatic variability may affect the recruitment and distribution of some top predator fish species (Section 3.10.1.5; Hollowed *et al.* 1998).

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fishery will continue to remove a sustainable portion of the Pacific halibut population, a top predator. The current management plan is likely to continue in the reasonably foreseeable future, although a modified approach has been proposed to produce a yield similar to the present policy while reducing variations in annual yield due to changes in stock abundance, assessment methods, and estimated removals by other fisheries (Clark and Hare 2003). High levels of seabird bycatch and resulting direct mortality are expected to continue annually from North Pacific Ocean longline fisheries operating outside of the EEZ. Available data and estimates for the annual incidental take of individual bird species by these external fisheries are provided and discussed in Sections 3.7.1-19. The State of Alaska directed groundfish fisheries, operating in state waters of the eastern GOA and southeast Alaska, Cook Inlet, PWS, Kodiak, and the Alaska Peninsula, and in all state waters for lingcod, sablefish, and Pacific cod, will continue to remove targeted top predatory fish species in small numbers relative to the domestic groundfish fisheries in Federal waters (ADF&G 2003b). Subsistence harvests of marine mammals will continue in the future with an increasing trend toward co-management by NOAA Fisheries and Alaska Native organizations. The Protected Resources Division of NOAA Fisheries will continue to develop management and conservation programs to ensure that annual subsistence harvests are sustainable (NOAA Fisheries 2003). A large fuel or oil spill at sea would result in direct mortality of marine mammals, with mortality levels depending on the location, size, and timing of the spill. Finally, a future climatic regime shift could alter total numbers of top predators in the BSAI and GOA ecosystems by increasing or limiting recruitment.

- **Cumulative Effects.** A conditionally significant adverse cumulative effect on total numbers of top predators could result from FMP 2.2 in combination with continued high levels of seabird bycatch by North Pacific Ocean longline fisheries operating outside the EEZ. Because these external fisheries are generally not managed in conjunction with the BSAI and GOA domestic groundfish fisheries, there is a likelihood that the present high levels of seabird bycatch will continue in the reasonably foreseeable future. The conditions under which this cumulative effect could be significant are the continuation of high external seabird bycatch rates, intensified by contributions from a large fuel or oil spill and incremental removals of top predators by the IPHC longline fishery, State of Alaska directed groundfish fisheries, and subsistence harvests of marine mammals. As determined from recent climatic studies (Section 3.3), a climatic regime shift is probable in the future, and could intensify or reduce the potential cumulative effect by influencing recruitment.

Introduction of Non-Native Species

- **Direct/Indirect Effects.** The potential effects of FMP 2.2 on predator-prey relationships through the introduction of non-native species would be insignificant. The estimated catch levels are similar to recent catches in these areas, indicating a similar level of effort and thus a similar potential for fishing vessel introduction of non-native species through ballast water exchange or release of hull-fouling organisms.

- **Persistent Past Effects.** For decades the annual arrival of groundfish fishing vessels from ports outside of Alaska has made it possible for non-native species to enter Alaskan waters through the release of ballast water and hull-fouling organisms. Commercial shipping has provided a similar means for the introduction of non-native species (Fay 2002). There have been 24 non-indigenous species of plants and animals documented in Alaskan waters, with 15 of these recorded in PWS, where most of the research has been conducted. Although oil tankers, through the release of ballast

water, have been speculated to be the primary source for these introductions, cruise ships and fishing vessels coming from areas where invasive species have already been established have also been identified as a threat in the State of Alaska Aquatic Nuisance Species Management Plan (Fay 2002). From 1991 to 2001, 396,522 accidental escapes of Atlantic salmon were reported from British Columbia fish farms (ADF&G 2002a). Concerns have been expressed regarding the potential effects of introduced Atlantic salmon on native Pacific salmon populations, including diseases and parasites, colonization, interbreeding and hybridization, predation, habitat destruction, and competition, particularly in locations where depressed stocks of Pacific salmon species provide a potential niche for the Atlantic species (Brodeur and Busby 1998, ADF&G 2002a). In the past, Alaska's northern climate, geographic isolation, and small human population, among other factors, may have prevented the establishment of viable populations by non-native species introduced from more temperate regions (Fay 2002).

- **Reasonably Foreseeable Future External Effects.** IPHC longline fishery vessels, international longline and groundfish fleets operating outside the EEZ, and vessels participating in State of Alaska directed fisheries will continue to be potential sources of exotic introductions in the reasonably foreseeable future. In addition, commercial shipping, including cruise ships and barges and tankers with high-volume ballast water releases, will continue to bring non-native species into Alaskan waters on a recurring basis, maintaining a continuing pressure on indigenous populations (Fay 2002). Escapes and releases of farmed Atlantic salmon from Washington State and British Columbia net-pens might eventually establish runs in GOA coastal streams and rivers. Introduced pathogens and parasites associated with farmed Atlantic or Pacific salmon could infect wild stocks. A future regime shift or long-term warming trend could remove the protection that colder conditions may currently provide against exotic species, allowing viable non-native populations to become established.

- **Cumulative Effects.** When considering sources of exotic species external to the domestic groundfish industry in combination with FMP 2.2, it is conceivable that viable populations could become established in the BSAI and/or GOA in the future, producing a conditionally significant adverse cumulative effect (Table 4.1-7). One possible, but unproven, condition for this outcome would be a future climatic regime shift or long-term warming trend that may enable exotic species currently limited by low seawater temperatures to establish viable populations in the BSAI and/or GOA.

Energy Removal

- **Direct/Indirect Effects.** The effects of FMP 2.2 on energy removal are expected to be insignificant. Baseline energy removals, in the form of total catch, are less than one percent of the total ecosystem energy, as estimated by mass-balance modeling, and were determined to have an insignificant impact on the ecosystem. Total retained catch removals under FMP 2.2 would increase but are less than one percent of the total system energy as estimated from mass-balance modeling for the EBS. These estimated energy removals would not have the potential to produce significant changes in system biomass, respiration, production, or energy cycling outside the range of natural variability (Table 4.1-7).

- **Persistent Past Effects.** The domestic groundfish fisheries, State of Alaska commercial fisheries, IPHC longline fisheries, commercial harvests of marine mammals, and subsistence harvests have all removed biomass from the BSAI and GOA ecosystems, either as targeted species or as bycatch, and

these removals, in a regulated and mitigated form, continue today (Section 3.10). Aggregate biomass levels removed by unregulated past human activities would have been influenced by climatic effects on overall system productivity, with biomass removals increasing as productivity increased and decreasing with climate-related productivity declines.

- **Reasonably Foreseeable Future External Effects.** The IPHC longline fisheries, State of Alaska commercial fisheries, subsistence fish harvests, and subsistence marine mammal harvests will continue to remove biomass from the BSAI and GOA ecosystems in the future. The incremental contribution of the combined State of Alaska herring and crab and IPHC halibut fisheries is estimated at about 4 percent of the cumulative biomass that would be removed annually under this FMP (Table 4.5-81). The State of Alaska directed groundfish and subsistence fisheries will remove an additional small increment annually (ADF&G 2003b, 2001). It should be noted that Russian and other fisheries operating in the western Bering Sea and in international waters of the central Bering Sea (doughnut hole) will also remove biomass in the future, but these regions show sufficient differences from the EBS with respect to production regimes and topographic and hydrographic features that are viewed as only partly comparable systems, and their interactive components with the EBS, where present, have not yet been characterized (Aydin *et al.* 2002).

- **Cumulative Effects.** The implementation of FMP 2.2 would have an insignificant cumulative effect on energy removal in the future. The total domestic groundfish catch under this FMP is estimated to remove less than one percent of the total system energy. If the combined total catch of the State of Alaska herring and crab and IPHC halibut fisheries in the future is similar to the 1994-2002 average, the cumulative total catch of these external fisheries plus the BSAI and GOA groundfish fisheries will increase by about 5.3 percent over the estimated total catch for this FMP alone (Table 4.5-81). This additional increment of biomass removal is not considered sufficient to produce a long-term change in system biomass, respiration, production, or energy cycling outside the range of natural variability due to expected energy removals by the BSAI and GOA groundfish fisheries (Table 4.1-7).

Energy Redirection

- **Direct/Indirect Effects.** The effects of FMP 2.2 on energy redirection are expected to be insignificant. Projections for total discards are less than one percent of the estimate of unused detritus already going to the bottom under the baseline conditions, as determined from mass-balance modeling of the EBS. They would not produce long-term changes in system biomass, respiration, production, or energy cycling outside the range of natural variability due to fishery discarding and offal production practices (Table 4.1-7).

- **Persistent Past Effects.** Ecosystem energetics is a dynamic process and it is difficult to know whether past changes in energy cycling and pathways of energy flow in the BSAI and GOA produced effects that still persist. The most far-reaching changes in quantities and geographic patterns of bycatch discards and offal production from both fish and marine mammal harvests came with international agreements, legislation, and regulatory actions in the 1950s through the 1970s, culminating in passage of the MSA in 1976 (Section 3.10.1.3). These corrective actions greatly curtailed the destabilizing levels of energy redirection that reached their peak in the mid-twentieth century from commercial whaling, fur seal harvests, high-seas driftnet fisheries, and the international commercial groundfish and salmon fisheries that existed. It seems likely, therefore, that under

current management practices, quantities and patterns of energy redirection in the BSAI and GOA are much more limited than 50 years ago.

- **Reasonably Foreseeable Future External Effects.** Quantities and geographic patterns of bycatch discards and fish processing wastes released into the sea from the IPHC and State of Alaska commercial fisheries and from subsistence harvests are not expected to change substantially in the future. External energy will also enter the system as graywater and refuse released into the sea from commercial freighters, tankers, and cruise ships. The pattern of such disposal at sea is not expected to change much in the future. Finally, future climatic trends have the potential to affect energy cycling in the ecosystem; in particular, a warming trend would be expected to accelerate rates of energy conversion, whereas cooler conditions would tend to have a retarding effect.

- **Cumulative Effects.** The implementation of FMP 2.2 is predicted to have an insignificant cumulative effect on energy redirection. The cumulative effect of FMP 2.2 in combination with external sources is not expected to depart significantly from the comparative baseline condition as to produce long-term changes outside the range of natural variability. At the local level, water quality degradation can be expected from the release of fish processing offal into low-energy environments, such as coves and bays, where nutrients from these wastes can concentrate in sheltered waters and alter local patterns of energy cycling. Although this is not an ecosystem-level effect, it is noted as a consequence of commercial fishing that will continue into the future and that may increase under FMP 2.2. The discharge of offal from fish processing facilities and of graywater and other refuse from marine vessels into Alaskan waters is regulated through EPA and ADEC permitting programs.

Change in Species Diversity

- **Direct/Indirect Effects.** Predicted effects of FMP 2.2 on species diversity are rated as insignificant with respect to all groups except skates, sharks, and grenadiers, for which the potential effects on species diversity are unknown because of the paucity of information on these groups. Under FMP 2.2, bycatch of HAPC biota would increase by about 28 percent in the BSAI and decrease by about 3 percent in the GOA (Table 4.5-81). Area closures would most likely be sufficient to provide protection against species-level extinction for this group of sessile organisms, although more research on coral distributions is needed. Catch amounts of target species, prohibited species, seabirds, and marine mammals under FMP 2.2 would be insufficient to bring these species below minimum population thresholds. Although forage species population levels are not known, their relatively high turnover rates would most likely protect most of them from falling below minimum biologically acceptable limits.

- **Persistent Past Effects.** Although the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, the timing of various increases and decreases in species abundance of fish, seabirds, and marine mammals has not shown a consistent correlation with groundfish fishing intensity (Sections 3.10.1). With the notable exception of the Steller's sea cow extinction in the 1760s (Section 3.10.1.1), changes in species diversity have not characterized the BSAI and GOA ecosystems. Although no fishing-related species removals have been documented under fisheries management policies in effect during the past 30 years, elasmobranchs (sharks, skates, and rays) are particularly susceptible to removal, and benthic invertebrate (including HAPC) species are

susceptible to bottom trawling (Section 3.10.3). Seabirds have been particularly vulnerable to bycatch mortality, leading to reduced populations of some bird species below minimum biologically acceptable limits. Lack of data on seabird population trends prevents analysis of past effects of fisheries management or environmental change on most seabird species (Section 3.7), but commercial fisheries have been implicated in some declines through bycatch potential. Livingston *et al.* (1999) found that long-term increases and decreases in the abundance of selected BSAI invertebrate, fish, bird, and marine mammal species did not show beneficial correlations with prey abundance, and that cyclic fluctuations in species abundance occurred in both fished and unfished species. As emphasized in Section 3.10.1.5, evidence is accumulating that physical oceanographic factors, particularly climate, have a controlling influence on biological community composition in the BSAI and GOA.

- **Reasonably Foreseeable Future External Effects.** Although past levels of seabird bycatch by the IPHC, western Bering Sea, and State of Alaska fisheries have not been thoroughly or consistently quantified, they are considered substantial and can be expected to continue in the future (Section 3.7). In addition, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, beluga whales, harbor seals), may deplete numbers to levels near or below biologically acceptable limits in the future. The potential for introduced exotic species to establish viable populations in the BSAI and GOA will also continue. Such exotics may include Atlantic salmon escapes from net-pen farms, invertebrates and plants introduced through ballast water and from ship hulls, and pathogens introduced by Pacific salmon species that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and make it easier for introduced exotics to establish viable populations.

- **Cumulative Effects.** Under FMP 2.2 , a conditionally significant adverse cumulative effect on species diversity could result from a high level of seabird bycatch by the IPHC longline fishery, western Bering Sea fisheries, and State of Alaska commercial fisheries, in combination with the BSAI and GOA groundfish fisheries. In addition, one or more introduced exotic species may establish a viable population that would change species diversity in a adverse way by competing with native species for food and habitat (Fay 2002). The consistent, sustained concentration of harvest effort on particularly accessible sub-populations of marine mammals from year to year could intensify this effect. Finally, climate change has the potential to alter species productivity and distribution, and a long-term warming trend might facilitate the establishment of viable populations by one or more exotic species.

Change in Functional (Trophic) Diversity

- **Direct/Indirect Effects.** Potential effects on trophic diversity relate to changes in the variety of species within trophic guilds. The greater the diversity of species within guilds, the more resilient the ecosystem is likely to be, because competing species within the same guild can replace or substitute for one another in response to environmental stressors, thereby maintaining the structure of the food web. Under FMP 2.2, the predicted effects of the groundfish fisheries on trophic diversity are rated as insignificant. This reflects the similarity of the expected species composition and amounts of removals, bottom gear effort, and bycatch amounts of HAPC biota under this FMP (Table 4.5-82, Figures H.4-31 and H.4-32 of Appendix H) to the baseline, for which fishing impacts on trophic diversity were determined to be insignificant.

- **Persistent Past Effects.** It is considered unlikely that past removals of fish by the pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries significantly affected the variety of species within trophic guilds. Livingston *et al.* (1999) found no evidence that groundfish fisheries had caused declines in trophic guild diversity for the groups studied. They also found that past changes in species diversity within guilds related to increases in a dominant guild member (e.g., pollock, rock sole) rather than to decreases in abundance caused by fishing pressure (Section 3.10.3). Past variations in climate, such as ENSO events, interdecadal oscillations, and regime shifts, may have affected trophic diversity by influencing the productivity and distribution of different species in different ways, thereby altering the relative proportions of species within guilds. However, little research on this type of effect was conducted in the BSAI and GOA in past decades.

- **Reasonably Foreseeable Future External Effects.** NOAA Fisheries and ADF&G biologists have recently brought attention to the potential for escaped farmed Atlantic salmon to establish viable Alaskan populations in competition with one or more of the five Pacific salmon species and steelhead (Brodeur and Busby 1998, ADF&G 2002a, Fay 2002). In addition, the concentrated take of marine mammals from the same local subpopulations over a period of years could affect species diversity within piscivore guilds, that is, guilds consisting of fish-eating species. Releases of ballast water and hull-fouling organisms introduced to BSAI and GOA waters from fishing vessels and commercial shipping could also lead to the establishment of viable populations in competition with native species at similar trophic levels (Fay 2002). A climatic regime shift in the future could affect trophic diversity by forcing trends that expand some trophic levels and contract others, and a long-term warming trend could facilitate the establishment of relatively cold-intolerant exotic populations.

- **Cumulative Effects.** The implementation of FMP 2.2 could produce a conditionally significant adverse effect on trophic diversity. The condition under which this potential effect could be significant relates to the additive effect of incremental contributions from several possible sources. If the farming of Atlantic salmon along the Pacific coast continues or increases, there is a potential for escaped or released fish to establish one or more viable populations in the reasonably foreseeable future, thus adding a new salmonid to the trophic structure. Other exotic species introduced through commercial shipping and fishing vessels also have the potential to establish viable populations, especially if facilitated by a favorable long-term climatic change, and thus alter trophic diversity. In addition, subsistence mammal harvests, particularly where individual subpopulations are placed consistently under pressure from year to year, have the potential to affect species diversity within piscivore guilds, at least locally. None of these potential external effects is likely to be interactive or synergistic with the direct/indirect effects of FMP 2.2, because different trophic guilds would be affected, but an additive effect is possible.

<u>Change in Functional (Structural Habitat) Diversity</u>

- **Direct/Indirect Effects.** The issue of concern with respect to structural habitat diversity is the removal, by bottom gear, of HAPC biota such as corals, sea anemones, and other sessile invertebrates that provide physical structures used as habitat by other species, including economically important groundfish species and their prey. It is important to ensure that the spatial distribution of areas closed to bottom fishing is broad enough, relative to coral distribution in particular, to allow these organisms to fulfill their functional role. Present (comparative baseline) trawl closures to protect the Steller's sea lion are spread throughout the Aleutian chain, but these

closures may be farther inshore than most of the coral. Because the areas that would be closed to trawling under FMP 2.2 would show little change from the comparative baseline conditions, the potential direct/indirect effects of FMP 2.2 are rated as insignificant.

- **Persistent Past Effects.** Bottom-trawling by the pre-MSA international groundfish fisheries, groundfish fisheries after passage of the MSA in 1976, and State of Alaska scallop fisheries have all contributed to the damage or depletion of the structural habitat functional guild in past years. Because little is known about the taxonomic structure of benthic communities of the BSAI and GOA, any past effects of trawling and other fishing-related activities on the species diversity of these communities cannot be quantified. Long-term climatic trends may also have influenced HAPC species through effects on their productivity and distribution, but in the absence of data no conclusions can be made.

- **Reasonably Foreseeable Future External Effects.** The State of Alaska scallop fishery will employ bottom dredges that will continue to damage or remove structural habitat provided by sessile invertebrates such as corals, sea anemones, and sponges. This effect is not likely to be reduced in the future. In addition, a large oil or fuel spill from commercial shipping could contact areas covered by these sensitive bottom-dwelling organisms and damage or kill them. A climatic regime shift could change the mean annual seawater temperature sufficiently to increase or retard the growth of benthic organisms, thereby altering structural habitat diversity.

- **Cumulative Effects.** The implementation of FMP 2.2 may produce a conditionally significant adverse effect on structural habitat diversity by adversely affecting benthic HAPC biota. Effects of FMP 2.2, rated insignificant because they would show little change from existing circumstances, could be intensified under at least three conditions. First, the additive effect of the scallop fishery, which employs bottom dredges, could add to the effects of bottom trawling by the groundfish fisheries on HAPC biota. Second, a large petroleum spill could also damage these sensitive organisms. Third, a change in seawater temperature resulting from a climatic regime shift in the future could reduce the productivity, and thus the population size, as well as the distribution, of bottom-dwelling invertebrates that provide structural habitat.

<u>Change in Genetic Diversity</u>

- **Direct/Indirect Effects.** If FMP 2.2 were implemented, no target species would fall below MSST, and spatial/temporal management of TAC, other catch, and selectivity patterns in the fisheries would be similar to present conditions. Fishing pressure would not focus on specific spawning aggregations or systematically target older age classes that tend to have greater genetic diversity. Consequently, the effect of the groundfish fisheries on genetic diversity are expected to be insignificant under FMP 2.2. However, a baseline condition for genetic diversity remains unknown for most species and the actual effects that fishing could exert on genetic diversity under this FMP are also largely unknown.

- **Persistent Past Effects.** The pre-MSA international groundfish fisheries, the domestic groundfish fisheries after passage of the MSA in 1976, and the IPHC, State of Alaska, and subsistence fisheries have cumulatively removed large quantities of fish from the BSAI and GOA ecosystems in the past, but data are not available to indicate whether genetic diversity was measurably affected. As discussed in Section 3.10.3, if a fishery concentrates on certain spawning aggregations or on older (larger) age classes of a target species that tend to have greater genetic diversity (dating from an

earlier period when fishing was less intensive), then genetic diversity will tend to decline in fished versus unfished systems. It is possible that genetic diversity has already declined in the BSAI and GOA ecosystems, but this cannot be known in the absence of data. Genetic assessments of North Pacific pollock populations and subpopulations conducted by Bailey *et al.* (1999) have found genetic variations among different stocks, but these studies have not found genetic variability across time within the same stocks that might indicate effects from commercial fishing. Heavy exploitation of certain spawning aggregations existed historically (e.g., Bogoslof pollock), but recent and current spatial/temporal management of groundfish has been designed to reduce fishing pressure on spawning aggregations.

- **Reasonably Foreseeable Future External Effects.** Several external factors have the potential to affect the genetic diversity of the BSAI and GOA ecosystems. Atlantic salmon escapes from coastal net-pen farms in Washington State and British Columbia could establish Alaskan runs and viable populations (ADF&G 2002a, Fay 2002). Subsistence harvests of fish could concentrate effort on the same specific subpopulations from year to year, inadvertently but selectively depleting genetically distinct stocks. Similarly, subsistence harvests of some marine mammal species (Section 3.8), particularly those with relatively small and geographically distinct subpopulations (e.g, beluga whales, harbor seals), may also deplete genetic diversity. The potential for introduced exotic invertebrates to establish viable populations in the BSAI and GOA will unavoidably continue with fishing vessel and commercial shipping traffic in the future. Such exotics may also include pathogens introduced by Pacific salmon that have escaped from fish farms (Fay 2002, ADF&G 2002a, Brodeur and Busby 1998). Future climate changes could alter the productivity and distribution of individual species and enable introduced exotics to establish viable populations.

- **Cumulative Effects.** The implementation of FMP 2.2 is predicted to have an insignificant cumulative effect on genetic diversity. Several external factors, such as Atlantic salmon escapes, subsistence harvests of marine mammals that concentrate on the same subpopulations year after year, exotic species introduced through commercial shipping traffic, and climatic facilitation of viable exotic populations, have the potential to produce changes in the genetic diversity of the BSAI and GOA ecosystems. None of these, however, would directly involve the genetic diversity of species targeted or taken incidentally by the groundfish fisheries. For this reason, external sources of potential change in genetic diversity would not be additive or interactive with the groundfish fisheries in the future.

4.6.11 Summary of Alternative 2 Analysis

The direct, indirect and cumulative ratings for all resource categories analyzed under this alternative are summarized in Tables 4.6-1 through 4.6-7.

Table number	Resource category	Components	Section 4.6 reference
4.6-1	Target groundfish species	Bering Sea and Aleutian Islands (BSAI) and Gulf of Alaska (GOA) walleye pollock, BSAI and GOA Pacific cod, BSAI and GOA sablefish, BSAI and GOA Atka mackerel, BSAI yellowfin sole, GOA shallow water flatfish, BSAI rock sole, BSAI and GOA flathead sole, BSAI and GOA arrowtooth flounder, BSAI Greenland turbot, GOA deepwater flatfish, BSAI Alaska plaice, BSAI other flatfish, GOA rex sole, BSAI and GOA Pacific ocean perch, GOA thornyhead rockfish, BSAI and GOA northern rockfish, BSAI and GOA shortraker/rougheye rockfish, BSAI other rockfish, GOA slope rockfish, GOA pelagic shelf rockfish, GOA demersal shelf rockfish.	4.6.1
4.6-2	Prohibited, other, forage and non-specified species	Pacific halibut, Pacific salmon and steelhead trout, Pacific herring, crab. Other species category. Forage fish category. Grenadier.	4.6.2 4.6.3 4.6.4 4.6.5
4.6-3	Habitat	BSAI, GOA	4.6.6
4.6-4	Seabirds	Black-footed albatross, laysan albatross, short-tailed albatross, northern fulmar, shearwaters, storm-petrels, cormorants, spectacled eider, Seller's eider, jaegers, gulls, kittiwakes, terns, murres, guillemots, murrelets, auklets, puffins.	4.6.7
4.6-5	Marine mammals	Steller sea lion, northern fur seals, Pacific walrus, harbor seals, spotted seal, bearded seal, ringed seal, ribbon seal, northern elephant, sea otter, blue whale, fin whale, sei whale, minke whale, humpback whale, gray whale, northern right whale, bowhead whale, sperm whale, beaked whales (Baird's, Cuvier's and Stejneger's), Pacific white-sided dolphin, killer whale, beluga whale, harbor porpoise, Dall's porpoise.	4.6.8
4.6-6	Socioeconomics	Harvesting and processing sector (catcher vessels, catcher processors, inshore processors and motherships). Regional socioeconomic profiles (population, processing ownership and activity, catcher vessel ownership and activity, tax revenue, employment and income). Community development quota (CDQ) allocations. Subsistence (subsistence use of groundfish, subsistence use of Steller sea lions, salmon subsistence fisheries, indirect subsistence factors: income and joint production). Environmental justice. Market channels and benefits to United States consumers (product quantity, product year-round availability, product quality, product diversity). Non-market goods (benefits derived from marine ecosystems and associated species).	4.6.9.1 4.6.9.2 4.6.9.3 4.6.9.4 4.6.9.5 4.6.9.6 4.6.9.7
4.6-7	Ecosystem	Forage fish availability, spatial/temporal concentration of fisheries, introduction of non-native species, removal of top predators, energy redirection, energy removal, species diversity, guild diversity, genetic diversity.	4.6.10

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