UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
P.O. Box 21668
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Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion

Alaska Fisheries Science Center Surveys in the Gulf of Alaska, Bering Sea/Aleutian Islands, and Chukchi Sea/Beaufort Sea Research Areas, 2019-2022
and the
International Pacific Halibut Commission Surveys in the Gulf of Alaska and Bering Sea, 2019-2022

Environmental Consultation Organizer (ECO) Number: AKRO-2017-00028

Action Agencies: National Marine Fisheries Service, Office of Protected Resources, Permits and Conservation Division (PR1)
National Marine Fisheries Service, Alaska Fisheries Science Center (AFSC)

Summary Table 1. Affected Species and Determinations

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Blue whale (*Balaenoptera musculus)* Eastern North Pacific	Endangered	Yes	No	N/A
Sei whale (*Balaenoptera borealis*) Eastern North Pacific	Endangered	Yes	No	N/A
Beluga whale (*Delphinapterus leucas*) Cook Inlet DPS	Endangered	Yes	No	No
Fin whale (*Balaenoptera physalus*) Northeast Pacific	Endangered	Yes	No	N/A
Humpback whale (*Megaptera novaeangliae*) Western North Pacific DPS	Endangered	Yes	No	N/A
Humpback whale (*Megaptera novaeangliae)* Mexico DPS	Threatened	Yes	No	N/A
Sperm whale (*Physeter macrocephalus)* North Pacific	Endangered	Yes	No	N/A
Bowhead whale (*Balaena mysticetus)* Western Arctic	Endangered	Yes	No	N/A
North Pacific right whale (*Eubalaena japonica)*	Endangered	Yes	No	No
Bearded seal (*Erignathus barbatus)*	Threatened	Yes	No	N/A
Ringed seal (*Phoca hispida)*	Threatened	Yes	No	N/A
Steller sea lion (*Eumetopias jubatus)* Western DPS	Endangered	Yes	No	No

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Green Sturgeon (*Acipenser medirostris*) Southern DPS	Threatened	Yes	No	No
Chinook salmon (*Oncorhynchus tshawytscha*)				
Lower Columbia River	Threatened	Yes	No	No
Upper Columbia River Spring		Yes	No	No
Puget Sound	Threatened	Yes	No	No
Snake River Fall	Threatened	Yes	No	No
Snake River Spring/Summer	Threatened	Yes	No	No
Upper Willamette River	Threatened	Yes	No	No
Chum salmon (*Oncorhynchus keta*) Hood Canal summer-run	Threatened	Yes	No	No
Columbia River	Threatened	Yes	No	No
Coho salmon (*Oncorhynchus kisutch*) Lower Columbia River	Threatened	Yes	No	No
Sockeye salmon (*Oncorhynchus nerka*)				
Lake Ozette	Threatened	Yes	No	No
Snake River	Endangered	Yes	No	No
Gray whale (*Eschrichtius robustus*) Western North Pacific	Endangered	No	No	N/A
Green turtle (*Chelonia mydas*) Central N. Pacific DPS and East Pacific DPS	Threatened	No	No	N/A
Loggerhead turtle (*Caretta caretta*) North Pacific Ocean DPS	Endangered	No	No	N/A
Olive ridley turtle (*Lepidochelys olivacea*)	Threatened	No	No	N/A
Leatherback turtle (*Dermochelys coriacea*)	Endangered	No	No	No
Steelhead trout (*Oncorhynchus mykiss*)				
Lower Columbia River DPS	Threatened	No	No	No
Middle Columbia River DPS	Threatened	No	No	No
Snake River Basin DPS	Threatened	No	No	No
Upper Columbia River DPS	Threatened	No	No	No
Upper Willamette River DPS	Threatened	No	No	No
Puget Sound DPS	Threatened	No	No	No

Consultation Conducted By: National Marine Fisheries Service, Alaska Region

Issued By: for ______________________
James W. Balsiger, Ph.D.
Regional Administrator

Date: ____April 5, 2019_______

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Glossary of Abbreviations

ABC	Acceptable Biological Catch
ABL	Auke Bay Laboratory
ACES	Arctic Coastal Ecosystem Surveys
ADCP	Acoustic Doppler Current Profiler
ADFG	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
AFSC	Alaska Fisheries Science Center (NMFS)
AI	Aleutian Islands
AIS	Automated Identification System
AKR	Alaska Region (NMFS)
APPS	Authorizations and Permits for Protected Species
ASAMM	Aerial Surveys of Arctic Marine Mammals
AWT	Aleutian Wing Trawl
BA	Biological Assessment (under the ESA)
BC	British Colombia
BiOp	Biological Opinion (under the ESA)
BMP	Best Management Practice
BRT	Biological Review Team
BSAI	Bering Sea/Aleutian Islands
BSAIRA	Bering Sea and Aleutian Islands Research Area
BWASP	Bowhead Whale Feeding Ecology Study
CAA	Conflict Avoidance Agreement
CFR	Code of Federal Regulations
CI	Confidence Interval
CIB	Cook Inlet beluga whale
CPUE	Catch Per Unit Effort
CSBSRA	Chukchi Sea Bering Sea Research Area
CTD	Conductivity Temperature Depth
CV	Coefficient of Variation
CWA	Clean Water Act
CWT	Coded Wire Tag
DART	
DAS	Days At Sea
DIDSON	Dual Frequency Identification Sonar
DPEA	Draft Programmatic Environmental Assessment
dB	decibels
dB μPa rms	decibels referenced to one micro Pascal root-mean-square
DPS	Distinct Population Segment
DQA	Data Quality Act
EcoFOCI	Ecosystems & Fisheries – Oceanography Coordinated Investigations
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EMA	Ecosystem Monitoring and Assessment
EPA	U.S. Environmental Protection Agency
ESCA	Endangered Species Conservation Act (1970)
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit

EVOSTEC	
FMP	Fishery Management Plan
FISHPAC	
FMZ	Fishery Management Zone
FOCI	
FR	Federal Register
F/V	Fishing Vessel
GIS	Geographic Information System
GOA	Gulf of Alaska
GOARA	Gulf of Alaska Research Area
GT	Gross Tonnage
HARP	High-frequency Acoustic Recording Package
HCS	Hood Canal summer (chum salmon)
HOR	Hatchery Origin
Hz	Hertz
IDFG	Idaho Department of Fish and Game
IMO	International Maritime Organization
IPHC	International Pacific Halibut Commission
ITS	Incidental Take Statement (under the ESA)
IUCN	International Union for the Conservation of Nature
IWC	International Whaling Commission
kHz	kilohertz
LAA	Likely to Adversely Affect
LCR	Lower Columbia River
LE	Limited Entry
LF	Low Frequency cetacean functional hearing group
LOA	Letter of Authorization (under the MMPA)
LOF	List of Fisheries (under the MMPA)
MARPOL	
MCR	Middle Columbia River
MF	Mid-Frequency
MLLW	Mean Low Low Water
MML	Marine Mammal Laboratory
MMPA	Marine Mammal Protection Act
MPA	Marine Protected Areas
MPG	Major Population Group
M&SI	Mortality & Serious Injury
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NLAA	Not Likely to Adversely Affect
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory (NMFS)
NOAA	National Oceanic and Atmospheric Administration
NOR	Natural Origin
NPDES	National Pollutant Discharge Elimination System
NPFMC	North Pacific Fishery Management Council
NWFSC	Northwest Fisheries Science Center
NPRW	North Pacific right whale
ODFW	Oregon Department of Fish and Wildlife
OL	Ozette Lake

OLE	Office of Law Enforcement
OW	Otariid Pinniped functional hearing group
PBF	Physical or Biological Feature
PBR	potential biological removal
PCE	primary constituent element
PNE	Poly Nor'Eastern
PNW	Pacific Northwest
ppm	parts per million
PR1	Office of Protected Resources (NMFS Headquarters)
PRD	Protected Resources Division (NMFS)
PS	Puget Sound
PSBT	Plumb Staff Beam Trawl
PSO	Protected Species Observer
PSTRT	Puget Sound Technical Recovery Team
PTS	Permanent Threshold Shift
PW	Phocid pinniped functional hearing group
RCA	Rookery Cluster Area
rms	sound source level, measured in dB re 1 μPa
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measure
R/V	Research Vessel
SAR	Stock Assessment Report
SECM	Southeast Alaska Coastal Monitoring
SPL	Sound Pressure Level
SPLASH	Structure of Populations, Levels of Abundance & Status of Humpbacks
SR	Snake River
SRP	Scientific Research Permit
SSL	Steller sea lion
SWFSC	Southwest Fisheries Science Center
TAC	Total Allowable Catch
TMAA	Temporary Maritime Activities Area
TSMRI	Ted Stephens Marine Research Institute
TTS	Temporary Threshold Shift
UCR	Upper Columbia River
UME	Unusual Mortality Event
UNOLS	University National Oceanographic Laboratory
URB	Up-river bright
U.S.C.	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
UWR	Upper Willamette River
VSP	Viable Salmonid Population
WCR	West Coast Region (NMFS)
WDFW	Washington Department of Fish and Wildlife
wDPS	Western Distinct Population Segment
WLC-TRT	Willamette/Lower Columbia River Technical Recovery Team
WNP	Western North Pacific

1. INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1536(a)(2)) requires each Federal agency to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a Federal agency's action "may affect" a protected species, that agency is required to consult with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR §402.14(a)). Federal agencies may fulfill this general requirement informally if they conclude that an action may affect, but "is not likely to adversely affect" endangered species, threatened species, or designated critical habitat, and NMFS or the USFWS concurs with that conclusion (50 CFR §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS and/or USFWS provide an opinion stating how the Federal agency's action is likely to affect ESA-listed species and their critical habitat. If incidental take is reasonably certain to occur, section 7(b)(4) requires the consulting agency to provide an incidental take statement (ITS) that specifies the impact of any incidental taking, specifies those reasonable and prudent measures necessary or appropriate to minimize such impact, and sets forth terms and conditions to implement those measures.

The action agencies in this opinion are described below.

1. The Alaska Fisheries Science Center (AFSC) carries out research activities which may affect ESA-listed species in the Gulf of Alaska Research Area (GOARA), Bering Sea and Aleutian Islands Research Area (BSAIRA), and the Chukchi Sea and Beaufort Sea Research Area (CSBSRA). These research areas are presented in Figure 1. AFSC contracts with the Alaska Department of Fish and Game (ADF&G) to collect groundfish abundance and size composition data in conjunction with the ADFG Large-mesh Trawl Survey of Gulf of Alaska and Eastern Aleutian Islands via an annual contract process. AFSC also contracts with charter vessels to conduct various research activities throughout the action area (Tables 1-3). Surveys conducted pursuant to these contracts are analyzed in the opinion. Contracts between the AFSC and ADF&G and between AFSC and charter vessels to perform these research activities will include the applicable mitigation, monitoring, and reporting requirements outlined in this consultation.
2. The International Pacific Halibut Commission (IPHC) conducts research activities which may affect ESA-listed species in the GOARA and the BSAIRA. For purposes of ESA and compliance with the Marine Mammal Protection Act of 1972 (MMPA), the AFSC sponsors IPHC scientific research activities through Letters of Acknowledgement that are issued by the AFSC to the IPHC pursuant to the Magnuson-Stevens Fishery Conservation and Management Act and implementing regulations (50 CFR 600.745(a)). For each scientific research activity occurring in waters off Alaska, the AFSC reviews scientific research plans submitted by the IPHC, and after confirming the scientific research plan constitutes scientific research aboard a scientific research vessel as defined by regulation (50 CFR 600.10), the AFSC issues Letters of Acknowledgement to the IPHC. Letters of

Acknowledgement issued to the IPHC by the AFSC as part of this consultation will include the applicable mitigation, monitoring, and reporting requirements outlined in this consultation.

3. The Office of Protected Resources (PR1) proposes to promulgate regulations pursuant to MMPA, as amended (MMPA; 16 U.S.C. 1361-1407), related to AFSC research activities that may affect ESA-listed species. The regulations propose to authorize the issuance of a Letter of Authorization (LOA) that will allow the AFSC to “take” marine mammals incidental to the proposed action. The Federal action of issuing an LOA to the AFSC is also considered in this biological opinion (opinion).

The consulting agency for this proposal is NMFS’ Alaska Region (AKR) Protected Resources Division (PRD). Effects from this action on fish species were analyzed by NMFS West Coast Region (WCR), the agency’s species experts on Pacific salmonids and green sturgeon. This document represents NMFS’ biological opinion on the effects of these actions on endangered and threatened species and designated critical habitats.

The opinion and incidental take statement were prepared by NMFS in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1544), and implementing regulations at 50 CFR Part 402.

The opinion and ITS are in compliance with the Data Quality Act (44 U.S.C. 3504(d)(1)) and underwent pre-dissemination review.

1.1 Background

This opinion considers the effects of research activities conducted in Southeast Alaska, Gulf of Alaska, Aleutian Islands, and Bering, Chukchi, and Beaufort Seas. These actions have the potential to affect the threatened and endangered species and designated critical habitats listed in the Summary Table 1.

This opinion is based on information provided in the Biological Assessment (BA) (NMFS 2017b); September 2017 request for rulemaking and Letter of Authorization (LOA) under the MMPA (NMFS 2017f); Draft Programmatic Environmental Assessment (NMFS 2017d); *Federal Register* Notice for the proposed LOA (83 FR 37638; August 1, 2018); email and telephone conversations between PRD, AFSC, IPHC, and PR1 staff; published literature; and other sources of information. A complete record of this consultation is on file at NMFS’ Juneau, Alaska office.

This is a programmatic consultation and follows NMFS guidance (NMFS 2017e) on addressing suites of frequently occurring or routine actions being implemented in particular geographic areas. The activites subject to this opinion are frequently occurring, routine activities being implemented in particular locations, including future site-specific actions and related measures to minimize or avoid adverse effects from those future actions. This opinion includes project design criteria, best management practices, and standard operating procedures that inform the effects analysis and that ensure conservation needs of ESA-listed species are met for the activities under this programmatic consultation. The approach taken in this type of programmatic consultation facilitates evaluation and monitoring of the aggregate of agency actions and at a broader scale, while allowing NMFS and action agencies to develop and refine measures that avoid and minimize impacts to ESA-listed species and that aid in species recovery.

NMFS, AFSC, IPHC, and PR1 have worked together to develop project design criteria, best management practices, mitigation measures, and standard operating procedures specific to the common elements or aspects of the proposed action that will apply to all of the research activities covered by the programmatic consultation during the next five years. These common components limit the actions included in the programmatic consultation to those that are expected to result in predictable effects to ESA-listed species. AFSC, IPHC, and PR1 look to those common components developed through this consultation when research activities are modified to determine whether that modification is covered under the programmatic consultation or whether the action should be subject to a separate ESA section 7(a)(2) consultation. As discussed in the mitigation measures included in this opinion, monitoring reports and adaptive management through end of season meetings will help to judge the efficacy, implementation, and compliance of the opinion’s mitigation measures, best management practices, and standard operating procedures. NMFS anticipates that the suite of research activities covered under this opinion are likely to cause take, so an incidental take statement (ITS) is provided with this programmatic biological opinion.

1.1 Consultation History

In July 2015, AFSC submitted an LOA application to PR1 for the taking of cetaceans and pinnipeds in conjunction with their research activities in waters off Alaska from 2018−2023. On September 10, 2017, AFSC submitted a revised LOA application that included IPHC research activities (NMFS 2017f)

Numerous meetings and phone calls were held to coordinate efforts from AFSC, IPHC, WCR, and PRD prior to PRD receiving a draft biological assessment (BA) in August 2017. After additional review and questions, PRD received updated draft versions of the BA in September and November 2017.

On December 20, 2017, PR1 submitted a request to initiate section 7 consultation to PRD. On January 16, 2018, AFSC submitted a request to initiate section 7 consultation to PRD and submitted a final version of the BA (NMFS 2017b). PRD deemed the initiation package complete and initiated consultation with PR1 and AFSC on January 17, 2018. Subsequent requests for additional information were handled via email, phone, and in person throughout the spring and summer of 2018.

On April 18, 2018, PRD provided PR1, AFSC, and IPHC with a copy of the draft biological opinion. AFSC, IPHC, and PR1 submitted comments on the draft opinion in April 2018. NMFS Alaska Region reviewed all comments submitted and revised the opinion as warranted.

2. DESCRIPTION OF THE PROPOSED ACTION AND ACTION AREA

2.1 Proposed Action

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies. “Interrelated actions” are those that are part of a larger action and depend on the larger action for their justification. “Interdependent actions” are those that have no independent utility apart from the action under consideration (50 CFR 402.02).

The primary action considered under this opinion is the continuation of AFSC fisheries and ecosystem research activities as described in Table 1 and proposed future activities in Table 2. The information developed from these research activities is essential to the development of a broad array of fisheries, marine mammal, and ecosystem management actions taken not only by NMFS, but also by other federal, state, and international authorities.

IPHC research surveys are conducted in U.S. waters in the Gulf of Alaska (GOA), Bering Sea and Aleutian Islands (BSAI), and U.S. West Coast. The bulk of the survey effort is the IPHC Fishery-independent Setline Survey (IPHC Survey). The IPHC Survey is conducted annually, with some modifications as stations may be added or removed or effort (number of skates fished) at each station adjusted. Other research projects may last multiple years, continue with modifications, or only last one year and are not continued.

AFSC and IPHC research activities are divided into three primary components which are described in more detail in the tables cited below and adapted from the BA (NMFS 2017b):

1. Current AFSC fisheries and ecosystem research (Table 1);
2. Proposed AFSC research activities (Table 2); and
3. IPHC research activities (Table 3).

This action (and Tables 1-3) includes research activities that have occurred in recent years and similar research activities with similar effects on marine mammal species that may or may not occur in the foreseeable future

These activities occur in areas inhabited by marine mammals, sea turtles, and fishes listed under the ESA as threatened or endangered and inside designated critical habitat, as discussed in the *Action Area* section. This opinion evaluates impacts on ESA-listed marine species and designated critical habitat into the foreseeable future.

NMFS recognizes that while some elements of the research activities change each year (equipment, gear, exact locations of survey stations) in response to availability of funding, availability of chartered vessels, research directives, and randomized design, the general types of activities addressed by this consultation are expected to continue into the reasonably foreseeable future, along with the associated impacts. Therefore, as part of our effects analysis, we assumed that the research activities conducted by AFSC and IPHC during the period of PR1's proposed LOA pursuant to the MMPA would continue into the reasonably foreseeable future at levels similar to those assessed in this opinion and described in the NEPA analysis (NMFS 2017d).

PR1's issuance of proposed regulations and subsequent LOA under Section 101(a)(5)(A) of the MMPA (16 U.S.C. 1361) would govern the taking of small numbers of marine mammals incidental to the AFSC's and IPHC's research activities. The opinion considers the effects of issuing a LOA for the proposed action through December 31, 2023.

2.1.1 Current AFSC Research Activities

Current AFSC fisheries and ecosystem research surveys and projects are described in Table 1. Research is conducted in the GOARA, BSAIRA, and CSBSRA. Within the research areas, the AFSC categorizes fisheries research by gear type. The primary gear types under consideration in this opinion are:

- Trawl
- Longline
- Gillnet
- Pot
- Seine
- Other miscellaneous gear including cameras and ROVs

If a survey or research project utilizes more than one gear type; it is categorized under the predominant gear type to avoid duplication or splitting projects into multiple components[1] (Table 1).

AFSC also conducts a variety of marine mammal research surveys and projects that may affect ESA-listed species and critical habitat. These activities receive research permits from PR1, and section 7 consultation is completed prior to issuance of the permits. Therefore, marine mammal research projects are not discussed further in this Opinion.

[1]Appendix A of the NEPA analysis (NMFS 2017c) describes the different gear types and vessels used. Appendix B of the NEPA analysis includes figures showing the spatial/temporal distribution of fishing gears used during AFSC research.

Table 1. Summary of current AFSC fisheries research conducted on NOAA vessels and NOAA-chartered vessels. NMFS anticipates using the same or similar chartered vessels into the foreseeable future.

Many surveys use more than one gear type; each survey/research project is listed under one predominant gear type to avoid duplication or splitting projects into multiple components in the table. See Appendix A of the NEPA analysis (NMFS 2017c) for descriptions of the different gear types and vessels used. Appendix B of the NEPA analysis (NMFS 2017c) includes figures showing the spatial/temporal distribution of fishing gears used during AFSC research. Mitigation measures are described in Section 1.2.3 of this opinion. Units of measurement are presented in the format data was collected. Colors used in Table 1 correspond to the Research Area shading in Figure 1. Abbreviations used in the table: ABC = Acceptable Biological Catch; ADCP = Acoustic Doppler Current Profiler; ADFG = Alaska Department of Fish and Game; AI = Aleutian Islands; AWT = Aleutian Wing Trawl; CTD = Conductivity Temperature Depth; DAS = days at sea; cm2 = square centimeter; CO2 = carbon dioxide; EcoFOCI/EMA = Ecosystems & Fisheries-Oceanography Coordinated Investigations / Ecosystem Monitoring and Assessment Program; ESA = Endangered Species Act; freq = frequency; ft = feet; hr = hour; in = inch; kHz = kilohertz; km = kilometer; kts = knots; L = liter; m = meter; max = maximum; MHz = megahertz; mi = miles; min = minutes; mm = millimeter; NA = Not Available or Not Applicable; nm = nautical miles; PNE = Poly Nor'eastern bottom trawl; PSBT = Plumb Staff Beam Trawl; TBD = to be determined; yr = year; ~ = approximately.

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
GULF OF ALASKA RESEARCH AREA (GOARA)							
Survey Using Trawl Gear							
Acoustic Trawl Rockfish Study	The acoustic-trawl rockfish study is conducted to assess whether the variance of survey biomass estimates for patchily-distributed rockfish could be reduced by allocating increased trawl sampling in high-density rockfish patches (as determined in real-time from acoustic backscatter).	Yakutat area of the Gulf of Alaska	Conducted in conjunction with Pollock Summer Acoustic Trawl Survey as funding allows; samples day and night	Large chartered fishing vessel	Bottom trawl with net sounders	Net type and size: PNE, as described above Tow speed: 3 kts Tow duration: 10 min Depth: 200-450 m Marport headrope and wing sounders, 40 kHz	59 trawls
					Fisheries echosounder system	SIMRAD EK60 echosounder frequencies: 38 and 120 kHz	Continuous
ADFG Large-mesh Trawl Survey of Gulf of Alaska and Eastern Aleutian Islands	Bottom trawl surveys are conducted annually to estimate the abundance and condition of Tanner crab and red king crab populations. Although the trawl survey was developed primarily to assess crab resources, this effort provides additional groundfish abundance and size composition data critical for fish stock assessment. One bottom trawl tow is made in each of approximately 380 stations. Survey areas are divided into inshore and offshore stations. The size of offshore stations average approximately 62.8 km^2 and inshore stations average approximately 19.6 km^2.	Gulf of Alaska - Aleutian Islands	Summer, annually, 30-90 DAS; daytime samples only	ADFG R/V *Resolution*	Bottom trawl with net sounders	Net type: Eastern otter trawl net Net size: 12.2 m (40 ft), headrope 400-mesh Tow speed: 2.6 kts Tow duration: 10-25 min Depth:15-263 m (49-863 ft) Marport headrope and wing sounders, 40 kHz	~ 380 trawls
Conservation Engineering *(see also effort conducted in the BSAIRA)*	We develop and test modifications to fishing gear and methods to reduce incidental effects on habitat and non-target fish. Development stages include: observation and analysis of fish behavior and gear performance with conventional gear, design modifications and iterative observations to confirm design functions, performance testing (bycatch reduction or reduced effect on habitat). Initial stages focus on observations with cameras and imaging sonar, while later stages use	Gulf of Alaska - Aleutian Islands	All seasons, annually; 7 DAS; daytime samples only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: Various commercial bottomtrawls Net size: Operating net width 18-24 m, height 4-8 m. Mesh size 8 in (forward sections) to 5.5-4 inch (aft sections). Footropes large bobbins or disks (18-24- inch diameter) with substantial (18-48 in) spacing in between Tow speed: 3-3.5 kts Tow duration: Experimental tows - 0.75-6.5 hrs; Depth: 66-154 m (217-505 ft) Marport headrope and wing sounders, 40 kHz	Variable, ranging 20-40 tows per season.

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
	comparisons of catches under commercial fishing conditions.				Mid-water Trawl	Net type: Various Commercial mid-water trawls Net size: Operating net width 75-136 m, height 10-20 m, with size highly dependent on vessel power. Very large meshes (128-64 m) forward tapering gradually to 4 inch in aft sections Tow speed: 3-3.5 kts Tow duration: Experimental tows - 0.75-3 hrs; Depth: 66-154 m (217-505 ft)	Variable, ranging 20-40 tows per season.
					High frequency net imaging	DIDSON unit 31 cm x 17 cm x 14 cm, 12 MHz	With tows
					Underwater camera in housing attached to net headrope	Camera and housing - The device is 20 x 9 x 4.5 in and is a complete integrated unit with internal LED light and battery. This is typically deployed on fishing gear by clipping it to the gear.	With tows
EcoFOCI/ EMA Age-1 Walleye Pollock Assessment Survey and Ecosystem Observations in the Gulf of Alaska	This survey assesses the distribution and condition of age-1 walleye pollock immediately after the first winter; evaluates recruitment potential of emergent age-1s, a full year prior to assessment during acoustic or bottom trawl surveys. Survey determines the abundance, distribution, size structure, and survival of other key economic and ecological species in the region, and investigates the effects of climate variability on transport pathways from spawning to potential nursery locations for juveniles.	Gulf of Alaska	Winter, biennially, 7-31 DAS; samples day and night	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: PNE, as described above Tow speed: 3-5 kts Tow duration: 20 min Depth: 150-700 m Marport headrope and wing sounders, 40 kHz	50 trawls
					Bongo Net	Net type: Plankton net Net size: 20 cm and 60 cm Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	250 tows with each bongo net
					CTD	Seabird 911 plus	250 casts
EcoFOCI/ EMA Young-of-the-Year Walleye Pollock Assessment Survey and Ecosystem Observations in the Gulf of Alaska	Research is critical to understanding how environmental variability and change affects abundance, distribution, and recruitment of commercially and ecologically important juvenile fishes. Provides an assessment of abundance and condition of age-0 walleye pollock prior to the onset of the first winter. Physical and biological data are collected and ecosystem observations are made.	Gulf of Alaska	Fall, biennially, 7-31 DAS; samples day and night	Large chartered fishing vessel or NOAA ship R/V *Oscar Dyson*	Mid-water trawl	Net type: Anchovy trawl or equivalent Net size: 12 m x 12 m, 3 mm cod end liner Tow speed: 2-3 kts Tow duration: depth dependent, up to 1 hr Depth: oblique to bottom (<200 m)	50-75 trawls
					Beam Trawl	Net type: beam trawl Net size: 1m x 1m, 3- mm mesh, 4 mm cod end liner Tow speed: 1 -2 kts Tow duration: 10 min Depth: 50-200 m	50-75 trawls

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
					Bongo Net	Net type: Plankton net Net size: 20 cm and 60 cm Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	200 tows with each bongo net
					CTD	Seabird 911 plus	200 casts
EVOSTC Long-term Monitoring - Apex Predators	This study will evaluate the impact by humpback whales and other apex predators on forage fish populations, and will continue to monitor the seasonal trends and abundance of humpback whales. Prey selection by humpback whales will be determined through acoustic surveys, visual observation, scat analysis, and prey sampling. Chemical analysis of blubber samples (stable isotopes and fatty acid analysis) will provide a longer term perspective on whale diet and shifts in prey type. These data will be combined in a bioenergetic model to determine numbers of fish consumed by whales, with the long term goal of enhancing the age structure modeling of population with better estimates of predation mortality. This project operates under ESA section 10 directed research permit for marine mammal work.	Gulf of Alaska and Southeast Alaska	All seasons, monthly, 7-31 DAS; samples day and night	Large chartered fishing vessel, motorized skiff	Mid-water Trawl	Net type: otter trawl Net size: 6 m headrope Tow speed: 2-3 kts Tow duration: 20 min Depth: 0-150	10 trawls
					Surface Trawl	Net type: otter trawl Net size: 6 m headrope Tow speed: 2-3 kts Tow duration: 20 min Depth: surface	10 trawls
					Bongo Net	Net type: 333/500-micron bongo net Net size: 0.5 m diameter Tow speed: 2 kts Tow duration: 15 min Depth: 1-300 m	50 tows
					Tucker Trawl	Net type: Tucker Trawl 500 micron Net size: 1x1 m Tow speed: 2 kts Tow duration: 15 min Depth: 1-300 m	50 tows
					Gillnet with pingers	Net type: scientific gill net Net size: 10 m x 2 m Mesh size: variable Set duration: 30 min Pingers: 10 kHz, 132 dB	10 sets
					Cast Net	Net type: cast net Net size: 12 ft diameter Mesh size: 1/4 in Set duration: 1 min	100 casts
					Dip Net	Net type: pool skimmer Net size: 0.25 m diameter Mesh size: 500-micron Set duration: 30 sec	50 samples

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Gulf of Alaska Biennial Shelf and Slope Bottom Trawl Groundfish Survey	Multi-species bottom trawl surveys are conducted to monitor trends in abundance and distribution of groundfish populations. The survey is based upon a stratified-random design and the area-swept method of estimating abundance. The crew identifies all living organisms, weighs and counts them, and takes biological samples from key groundfish species or other species of interest. The catch data is used to estimate relative abundance, and to determine annual ABC and TAC.	Gulf of Alaska - continental shelf and upper continental slope (out to 1000 m depth) from Islands of Four Mountains to Dixon Entrance	Summer, biennially, 225 DAS; daytime samples only	Three large chartered fishing vessels working collaboratively, 75 DAS each	Bottom trawl with net sounders	Net type: PNE, as described above Tow speed: 3 kts Tow duration: 15 min (1.4 km tow length) Depth: out to 1000 m depth	820 survey stations, 884 attempted stations
Pollock Summer Acoustic Trawl Survey - Gulf of Alaska	The objective of the survey is to estimate the mid-water abundance and distribution of walleye pollock in the GOA shelf. Acoustic data are collected along a series of parallel transects with a scientific echosounder. Five split-beam transducers (18, 38, 70, 120, and 200 kHz) are mounted on the vessel. Whenever sufficient echosign is encountered, trawl sampling is conducted to identify ensonified targets. Net sounders are used to position the trawl in the water column and monitor the catch taken. Physical oceanographic measurements are made throughout the cruise. New camera work (see also Table 2): We will build a prototype and up to 9 replicate low-cost 'camera traps', to unobtrusively determine the distribution of fish in relation to the seafloor. Replicate units are essential to provide adequate target densities and spatial coverage. Stereo-camera methods would be used to quantitatively determine the distribution of fishes relative to the seafloor during acoustic surveys.	Gulf of Alaska shelf/slope from approximately 50 m bottom depth out to 1000 m bottom depth between the Islands of Four Mountains and Yakutat Trough.	Summer, biennially, 60 DAS; daytime trawl sampling only but other listed work occurs at night.	NOAA ship R/V *Oscar Dyson;* Large chartered fishing vessel	Bottom trawl with net sounders	Net type: PNE, as described above Tow speed: 3 kts Tow duration:10-20 min Depth: 50-600 m Marport headrope and wing sounders, 40 kHz	20 trawls
					Mid-water Trawl with net sounders	Net type: AWT, as described above Tow speed: 3 kts Tow duration: 10 min-1 hr Depth: 50-600 m Simrad ITI door sensors, 40 kHz Simrad FS70 3rd wire, 200 and 333 kHz	100 trawls
					Small Mid-water Trawl	Net type: Methot or similar Tow speed: 3 kts Tow duration: up to 1 hr Depth: 50-600 m	10 tows
					Echosounder with five split-beam transducers	Frequencies: 18, 38, 70, 120, and 200 kHz	Continuous
					CTD	Seabird 911	120 casts
					Camera traps	Each unit will consist of paired consumer grade still cameras and strobe lights mounted on a robust frame (crab pot) lying on the seafloor. The camera will be triggered using an infra-red detector that will fire the cameras when a fish moves into the range of the camera lens.	Up to 10 deployments
Pollock Winter Acoustic Trawl Survey - Shelikof Strait	The objective of the survey is to collect acoustic and trawl data to estimate mid-water abundance and distribution of walleye pollock in the region surrounding Kodiak Island. Acoustic data are collected along a series of parallel transects with a scientific echosounder. Whenever sufficient	Gulf of Alaska - shelf/slope waters around Kodiak Island, including Shelikof Strait, Chirikof Island shelf break, Alitak Bay,	Winter, spring, annually, 7-31 DAS; samples day and night	NOAA ship R/V *Oscar Dyson*	Bottom trawl with net sounders	Net type: PNE, as described above Tow speed: 3 kts Tow duration: variable Depth: 50-300 m Marport headrope and wing sounders, 40 kHz	10 trawls

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
	echosign is encountered, trawl sampling is conducted to identify ensonified targets. Net sounders are used to position the trawl in the water column and monitor the catch taken. Physical oceanographic measurements are made throughout the cruise.	Barnabus Trough, Chiniak Trough, and Marmot Bay			Mid-water Trawl with net sounders	Net type: AWT, as described above Tow speed: 3 kts Tow duration: 10 min-1 hr Depth: 50-600 m Simrad ITI door sensors, 40 kHz Simrad FS70 3rd wire, 200 and 333 kHz	20 trawls
					Echosounder with five split-beam transducers	18, 38, 70, 120, and 200 kHz	Continuous
					CTD	Seabird 911	30 casts
Pollock Winter Acoustic Trawl Survey – Shumagin/Sanak Islands	The objective of the survey is to collect acoustic and trawl data to estimate mid-water abundance and distribution of walleye pollock in the Shumagin Islands area. Acoustic data are collected along a series of parallel transects with a scientific echosounder. Whenever sufficient echosign is encountered, trawl sampling is conducted to identify ensonified targets. Net sounders are used to position the trawl in the water column and monitor the catch taken. Physical oceanographic measurements are made throughout the cruise.	Gulf of Alaska - shelf waters surrounding the Shumagin Islands, Sanak Trough, Morzhovoi Bay, and Pavlov Bay. In alternate years, survey is expanded to include bays along the Kenai Peninsula and Prince William Sound.	Winter, annually, 7-31 DAS; samples day and night	NOAA ship R/V *Oscar Dyson*	Bottom trawl with net sounders	Net type: PNE, as described above Tow speed: 3 kts Tow duration: variable Depth: 50-300 m Marport headrope and wing sounders, 40 kHz	10 trawls
					Mid-water Trawl with net sounders	Net type: AWT Net size: as described above Tow speed: 3 kts Tow duration: 10 min-1 hr Depth: 50-600 m Simrad ITI door sensors, 40 kHz Simrad FS70 3rd wire, 200 and 333 kHz	20 trawls
					Echosounder with five split-beam transducers	18, 38, 70, 120, and 200 kHz	Continuous
					CTD	Seabird 911	30 casts
Rockfish Habitat Studies/Reproduction of Groundfish	The research will measure how the productivity of commercially important groundfish species varies with physical and biological changes to the ecosystem. Specific research objectives include examining the productivity of federally managed fish species in a variety of habitat types; specifically focusing on rockfish in high relief rocky/boulder, high relief sponge/coral, and low relief habitats and examining interannual variability of commercially important rockfish species maturity, fecundity, and reproductive development.	Gulf of Alaska - continental shelf region between Kodiak Island and Prince William Sound	Spring, annually, 7-31 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: Commercial bottom/pelagic trawl Net size: commercial trawl Tow speed: 3 kts Tow duration: 5-10 min Depth: 120-300 m Marport headrope and wing sounders, 40 kHz	4-8 tows/cruise
					Bongo Net	Net type: Bongo net Net size: 500-µm and 1000-µm Tow speed: 1-2 kts Tow duration: 5 min Depth: 5-10 m from bottom	13 tows
					Cameras	Paired video cameras housed and mounted in a metal frame. Deployment duration ~45 min Depth 45-100 m.	15 stations

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Rockfish Reproduction Charters	The overarching goal of this study is to re-examine and update maturity parameters for a variety of rockfish species found within the Gulf of Alaska including Pacific ocean perch, northern rockfish, rougheye rockfish, blackspotted rockfish, and shortraker rockfish.	Gulf of Alaska, directly offshore of the port of Kodiak, AK	Winter (November-January), 10 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: Commercial bottom/pelagic trawl Net size: commercial trawl Tow speed: 3 kts Tow duration: 5-45 min Depth: 80-350 m Marport headrope and wing sounders, 40 kHz	6 - 8 tows/cruise
Southeast Alaska Coastal Monitoring (SECM)	The Southeast Alaska Coastal Monitoring (SECM) project monitors intra- and inter-annual biophysical features in the coastal marine ecosystem in relation to the distribution, abundance, feeding, bioenergetics, and migratory behavior patterns of wild and hatchery juvenile salmon and associated epipelagic ichthyofauna. Sampling is conducted to identify processes or factors that influence growth and survival of salmon in different marine habitats along seaward migration corridors and in the Gulf of Alaska.	Gulf of Alaska, Inland Southeastern Alaska (Icy Strait, Clarence Strait)	Summer, monthly, 1-7 DAS; daytime sampling only	Large chartered fishing vessel	Surface Trawl	Net type: Nordic 264 surface rope trawl Net size: 20 m x 20 m Tow speed: 3 kts Tow duration: 20 min Depth: 1-20 m	96 trawls per year
					Bongo Net	Net type: Bongo tandum Net size: 0.6 m each ring (mesh 505 mu and 333 mu) Tow speed: 1 kts Tow duration: 15-45 min Depth: 1-200 m	64 samples per year
Surveys Using Longline Gear							
Alaska Longline Survey *(see also effort conducted in the BSAIRA)*	The purpose of the survey is to monitor and assess the status of sablefish and other groundfish resources in Alaska. The AFSC conducts an annual longline survey to assess and monitor sablefish and other groundfish resources. Whale depredation is a common occurrence during the survey by both killer whales (Bering Sea, Aleutian Islands, Western GOA, Central GOA) and sperm whales (Central GOA, Eastern GOA). Opportunistic whale depredation studies occur during the survey which are designed to help quantify the amount of depredation that is occurring.	Gulf of Alaska, Aleutian Islands, Bering Sea Slope	Summer, fall, alternates annually between GOA and BSAI, 30-90 DAS; daytime sampling only	Large chartered fishing vessel	Longline	Mainline length: 16 km Set Depth: bottom Gangion length: 1.5 m Gangion spacing: 2 m Hook size and type: 13/0 circle # of hooks and bait: 7,200 hooks baited with squid Soak time: 3 hrs	75 stations
Barotrauma and Tagging of Deep-water Rockfish	Short sets of longline gear (<300 hooks) are set in southeast Alaska to sample deep-water rockfish. Fish are tagged and immediately placed into pressurized tanks. Rockfish are also tagged and released ~200 ft, in the water column, but not on-bottom using weighted gear. In subsequent years there will be more efforts to tag and recapture tagged rockfish using the longline gear. Fish may also be fitted with acoustic tags.	Inland Southeastern Alaska	Summer, fall, spring, annually, 1-7 DAS; daytime sampling only	Large chartered fishing vessel, smaller boats	Longline	Mainline length: 600 m Set Depth: 200 m Gangion length: 0.5 m Gangion spacing: 10 m Hook size and type: 13/0 circle # of hooks and bait: <300 hooks Soak time: 2 hrs	7 sets
Surveys Using Seine or Gillnet Gear							

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Little Port Walter Research Station and Experimental Hatchery	Survey methods include a weir at Sashin Creek, fish aggregation device in the inner bay, fish culture and hatchery facilities, boat surveys and sampling, and freshwater sampling.	Inland Southeastern Alaska	All seasons; continual operation day and night	Large chartered fishing vessel, smaller boats	Gillnet with pingers	Net type: Monofilament Net size: 150 ft length x 15 ft depth Mesh size: 8 in stretch Set duration: used intermittently June-August, 2-4 hrs per set Pingers: 10 kHz, 132 dB	50 sets
					Beach Seine	Net type: Nylon Net size: 150 ft length x 30 ft depth Mesh size: 1in Set duration: Used intermittently July-August, 30 min per set	50 sets
					Cast Net	Net type: Monofilament Net size: 12 ft diameter Mesh size: 1/2 in Set duration: used intermittently May-September, 2 min per set	50 sets
					Hoop Net	Net type: Monofilament Net size: 150 ft length x 15 ft depth Mesh size: 8 in stretch Set duration: used intermittently June-August, 2-4 hrs per set	20 sets
					Fyke Net	Net type: Nylon Net size: 40 ft length Mesh size: ½ in Set duration: Used intermittently in fresh water only April-June, 4 hrs per set	20 sets
					Net Pen	Net type: Nylon Net size: 20 ft length x 20 ft width x 20 ft depth Mesh size: 3/8 in Set duration: Year-round	1 set
					Dip Net	Net type: Cotton Net size: 12 in length x 8 in width x 12 in depth Mesh size: ¼ in Set duration: Used intermittently Year-round, 30 sec per set	>100 sets
Projects Using Other Gears							
Acoustic Research and Mapping to Characterize EFH (FISHPAC) *(see also effort conducted in the BSAIRA and CSBSRA)*	This study collects acoustic and other environmental data in trawl survey areas to develop numerical habitat models for groundfish and shellfish. Bathymetric data are also collected for nautical chart updates.	Gulf of Alaska	Summer, triennially (rotate among three research areas), 21-25 DAS; samples day and night	NOAA ship R/V *Fairweather*	Scientific Single Beam and Multibeam Ecoshounders; Side-scan Sonar	Frequencies used: Single beam echosounder (38 kHz); multi-beam ecohosounders (50, 100 kHz); Side-scan sonar (180, 455 kHz)	Continuous
					SEABOSS bottom sampler	0.1 m^2 van Veen grap in frame with ~ 1 m^2 footprint; weight 295 kg; usually 2 grabs per station; depths <200 m	50 stations
					TACOS: 2-part towed camera system	0.8 m^2 combined footprint; 285 kg; usually 1 300-500 m tow per station; depths <200 m	20 stations

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
					Free-Fall Cone Penetrometer	Dropped from stationary or underway vessel to seafloor with < 3 m penetration. Cross-sectional area = 0.004 m^2; weight in air 49.7 kg.	92 stations
Auke Bay Lab (ABL) Dive Checkouts/Facilities Dives	ABL staff perform proficiency dives to keep diver's certification active, and to inspect and maintain the site's saltwater intakes.	Gulf of Alaska - Small dock in Auke Bay, Southeast Alaska	All seasons, monthly; daytime dives only	None	Diving	SCUBA / snorkeling	12
Alaska Sea Week Program	Auke Bay Laboratories (ABL) has been involved in Sea Week activities from the very beginning. Annually we provide interpretive programs for approximately 1,200 students, teachers and parents during the months of April and May.	Inland Southeastern Alaska	Spring, annually; daytime sampling only	None	Dip Net	Net size: 0.5 m Mesh size: 505-micron Set duration: 5 seconds	4 samples
					Ring Net	Net size: 0.5 m diameter Mesh size: 333-micron	4 casts
Auke Creek Weir and Research Hatchery	Study involves installing a 2-way weir at Auke Creek and annually operate the weir. All fish migrating to and from Auke Lake are captured and monitored. Hatchery operations include the retention of a limited number of adult salmon, the collection of gametes, incubation of eggs, and short-term rearing of fry for stocking into Auke Lake.	Inland Southeastern Alaska	All seasons, annually;continual operation day and night	None	Weir	Across mouth of Auke Creek	Continuous
Cold Water Coral Recruitment	Determine recruitment and recovery rates of the deep-water gorgonian coral *Calcigorgia spiculifera*, to help determine long-term effects of anthropogenic disturbances, such as commercial fishing, on the population dynamics of benthic habitats.	Gulf of Alaska - Kelp Bay, Southeast Alaska	Summer, biennially, 1-7 DAS; daytime sampling only	Large chartered fishing vessel	Diving (SCUBA / snorkeling)/ tags	Depth: <30 m	4
Deep Sea Coral and Sponge Distribution *(see also effort conducted in the BSAIRA)*	This project uses a combination of statistical modeling and ground-truthing to predict the distribution of coral and sponge species in the Aleutian Islands and Gulf of Alaska. The field study consists of 15-minute camera drops at randomly selected locations in the AI and GOA.	Gulf of Alaska, Aleutian Islands, Inland Southeastern Alaska	Opportunistic, spring, summer, fall, annually; intermittent, 30 DAS; daytime sampling only	Large chartered fishing vessel	Camera system	Stereo camera sled with two cameras four strobe lights contained in an aluminum frame. Designed to be drifted or towed along the seafloor at a distance of ~ 1 m off the seafloor. Tow duration is 15 min	~150 per year
Diver Training, Maintenance, and Collection Operations	Diver checkouts/training, recovery/ replacement of sea water system intake screens, retrieval of temperature loggers, collection of live aquarium specimens for outreach displays at the TSMRI, Kodiak Lab, and other similar operations.	Gulf of Alaska	Annually as needed, 5-7 DAS; daytime diving only	Motorized and unmotorized skiffs	Diving	SCUBA/ snorkeling	As needed
EcoFOCI/EMA Larval Walleye Pollock Assessment Survey and Ecosystem Observations in the Gulf of Alaska	This study assesses the abundance, distribution, size structure, and survival of larvae of key economic and ecological species (walleye pollock, Pacific cod, arrowtooth flounder, sablefish, rockfish), and investigates the effects of climate variability on the mechanisms leading to recruitment including transport pathways from spawning to potential nursery locations.	Gulf of Alaska	Spring, biennially, 7-31 DAS; samples day and night	Large chartered fishing vessel	Bongo Net	Net type: Plankton Net size: 20 cm and 60 cm Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	150 tows (20 cm bongo net) 150 tows (60 cm bongo net)
					Multiple-Opening and Closing Net	Net type: Plankton Net size: 1 m^2 Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 60 min Depth: 0 - 1000 m	30 tows

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
					Neuston Net	Net type: Plankton Net size: 0.25 m^2 Tow speed: 1.5 - 2.5 kts Tow duration: 10 min Depth: surface	150 tows
					CTD	Seabird 911	150 casts
Juvenile Sablefish Tagging	The goal of the cruise will be to tag and release juvenile sablefish with 1,000 numerical spaghetti tags and 80 surgically implanted electronic archival tags. Electronic archival tags will be programmed to continuously record temperature and depth, and both numerical and electronic tags will be recovered as sablefish recruit to the commercial fishery at ages 4 and 5.	Gulf of Alaska, Inland Southeastern Alaska - St. John the Baptist Bay, Salisbury Sound	Summer, annually, 14 DAS; daytime sampling only	Chartered vessel	Hook-and-Line/ Depth sounder/ Tags	4 rod-and-reel combos, fishing 3-4 2/0 hooks per jigging rig, with 3-4 oz bank sinkers. Squid is the bait.	Sample size is about 240 rod-hrs/yr over 5 days, with between 300-1000 of the target species tagged (sablefish) and roughly an equivalent number of bycatch species that are caught and released.
Octopus Gear Trial and Maturity Study	The primary objectives of this conservation engineering project are 1) to determine the best methods and gear rigging for fishing habitat pot gear for octopus (all species), and 2) to collect octopus specimens for biological and life-history research. Catch rates of different types and materials of habitat pots were recorded, and all octopus captured were identified to species, measured, and weighed. Any incidental catch and the majority of octopus were returned to the sea. A selected subset of octopus caught was retained for maturity analyses. All octopus captured were giant Pacific octopus.	Gulf of Alaska	Spring, summer, fall, weekly, 30-90 DAS; daytime sampling only	Chartered vessel	Different types of pots deployed on a longline	Mainline length: approximately 1 km Set Depth: 60-225 m Gangion length: 1-2.5 m Gangion spacing: 10-20 m Pots and traps constructed of variety of materials (plywood, spruce, plastic) 3-4 strings of 40-45 pots, no bait Soak time: up to 3 months	Discarded Alive: 199, Sampled: 120
Seasonal Distribution and Habitat Use of Managed Fish Species in Upper Cook Inlet, Alaska	This project is part of a regional initiative supporting the NOAA Fisheries Habitat Blueprint. Nearshore fishes in upper Cook Inlet will be sampled. Beach seine and small shrimp trawl will be used near Fire Island. Habitat types sampled will be determined by ShoreZone imagery but are largely limited to soft bottoms (e.g., mudflats).	Gulf of Alaska, Cook Inlet – Fire Island	May, July, September, 1-7 DAS; daytime sampling only	Motorized skiff	Bottom Trawl	Net type: small bottom trawl Net size: 5 m x 2.5 m x 1.2 m Towspeed: 3 kts Tow duration: 5 min Depth: 8 m	3 trawls per sampling location (2) per sampling period (3) for a total of 25 trawls annually
					Beach Seine	Beach seine	5 seine hauls per sampling location (2) per sampling period (3) for a total of 25 seine hauls

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Sun to Sea Science Camp	The camp schedule includes activities such as hydro acoustics to listen to whale vocalizations, beach seining, tide pool exploration, clam digging to get clams for Paralytic Shellfish Poisoning (PSP) testing, Ocean Acidification experiments, and boat trips to conduct oceanographic data collections.	Inland Southeastern Alaska	Summer, annually, 6 DAS; daytime sampling only	Chartered vessel	Beach Seine	Net size: 37 m x 5 m Mesh size: 3.2 mm Set duration: 10 min round haul	2 sets
					Ring Net	Net size: 0.5 m diameter Mesh size: 333 micron	4 per year
BERING SEA/ALEUTIAN ISLANDS RESEARCH AREA (BSAIRA)							
Surveys Using Trawl Gear							
Aleutian Islands Biennial Shelf and Slope Bottom Trawl Groundfish Survey	The AFSC conducts comprehensive bottom trawl surveys in the Aleutian Islands (AI) designed principally to monitor trends in abundance and distribution of groundfish populations. The AI Bottom Trawl Survey is a multi-species survey based upon a stratified-random design and the area-swept method of estimating abundance. The catch is processed by the scientific crew who identifies all living organisms, weighs and counts them, and takes biological samples from key groundfish species or other species of interest.	Aleutian Islands - continental shelf and upper continental slope (out to 500 m depth); from Islands of Four Mountains west to Stalemate Bank.	Summer, biennially, 30-90 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: PNE bottom trawl with roller gear Net size: 24 m head and footrope Tow speed: 3 kts Tow duration: 15 min Depth: out to 500 m Marport headrope and wing sounders, 40 kHz	420 survey stations sampled, 450 attempted stations on average
					SIMRAD EK60 echosounder	Freq: 38 kHz	Continuous
Arctic Ecosystem Integrated Survey *(see also effort conducted in the CSBSRA)*	Objectives include surveying distribution and abundance of pelagic fish species and biological and physical oceanographic indices to evaluate the effect of climate change on the health of pelagic fish in this region. The status of juvenile salmon populations are evaluated as a secondary objective.	Northern Bering Sea, Chukchi Sea - from 60N to 72N and from nearshore (20 m depth) to near the Russia/US border	Summer, fall, annually, 50 DAS; daytime sampling only	Large chartered fishing vessel	Mid-water trawl (for acoustic targets)	Net type: Marinovich or similar net Net size: 15 m horizontal by 5 m depth Tow speed: 1 to 3 kts Tow duration: 15 to 60 min Depth: 15 m to near bottom depths	35 trawls
					Surface Trawl	Net type: Cantrawl Net size: 55 m horizontal by 25 m depth Tow speed: 3 to 5 kts Tow duration: 30 min Depth: surface to 15 m depth	75 trawls
					Bongo Net	Net type: Bongo Net size: 2 x 60 cm with 505-micron mesh nets and 2 x 20 cm 150 micron mesh nets Tow speed: 1 kts Tow duration: 10 to 20 min Depth: surface to near bottom depth	75 tows
					SIMRAD ES60 echosounder	Freq: 38 kHz	Continuous

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Atka Mackerel Tag Movement and Abundance in the Aleutian Islands	Atka mackerel are tagged with t-bar spaghetti tags and recovered with bottom trawls. Fish are tagged and released inside and outside of trawls exclusion zones of Steller sea lions to estimate prey abundance and movement with respect to those fisheries closures. Abundance and movement of Atka mackerel are estimated with integrated tagging models using maximum likelihoods.	Aleutian Islands	Spring, summer, biennially, 7-31 DAS; samples day and night	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: Bering Sea Combo 101/130, modified with rock hopper footrope. Net size: 101 ft headrope, 130 ft footrope Tow speed: 2-3 kts Tow duration: 10-90 min Depth: 40-250 m Marport headrope and wing sounders, 40 kHz	Varies; total of 884 tows over 10 years
Bering Arctic Subarctic Integrated Survey (BASIS)	This survey is an integral part of the EMA/FOCI partnership designed to examine early marine ecology of important groundfish, western Alaska salmon, forage fish, and oceanographic indices affecting early marine and overwinter survival of groundfish.	Bering Sea Shelf, Bering Sea Slope	Summer, fall, biennially 50 DAS; samples day and night	Large chartered fishing vessel or NOAA Vessel R/V *Oscar Dyson*	Surface Trawl	Net type: Cantrawl Net size: 55 m width, 25 m depth Tow speed: 3.5 to 5 kts Tow duration: 30 min Depth: surface to 25 m depth	110
					Bongo Net	Net type: Bongo zooplankton Net size: 505 µm and 143 µm mesh Tow speed: 1 m/sec Tow duration: depends on depth Depth: surface to 1 m off bottom	200
Bering Sea Shelf Bottom Trawl Survey	The primary objectives of this survey are to provide the following: 1) Data on the distribution, abundance, and biological condition of commercially important groundfish and crab species for the North Pacific Fishery Management Council, 2) Catch per unit effort (CPUE) and size and age composition data for the commercial fisheries of the U.S., and 3) Support for special projects on the biology, behavior, and dynamics of key ecosystem components.	Bering Sea Shelf - from Bristol Bay north to latitude 62°N	Spring, summer, annually, 130 DAS; daytime sampling only	Large chartered fishing vessels, two vessels operating cooperatively	Bottom trawl with net sounders	Net type: 83-112 Eastern otter trawl Net size: 83 ft headrope, 112 ft footrope Tow speed: 3 kts Tow duration: 30 min Depth: 20 to 200 m Marport headrope and wing sounders, 40 kHz	376 stations, fixed sites
					Bottom trawl fished as a mid-water trawl	Net type: 83-112 Eastern otter trawl Net size: 83 ft headrope, 112 ft footrope Tow speed: 3 kts Tow duration: 30 min Depth: 20 to 200 m	25 samples per boat
					SIMRAD EK60 echosounder	Freq: 38 kHz	Continuous
Conservation Engineering *(see also effort conducted in the GOARA)*	See above-Gulf of Alaska	Gulf of Alaska - Aleutian Islands, Bering Sea Shelf, Bering Sea Slope	All seasons, annually, 14 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: Various commercial bottom trawls Net size: Operating net width 18-24 m, height 4-8 m. Mesh size 8 in (forward sections) to 5.5 to 4 in (aft sections). Footropes large bobbins or disks (18-24 in diameter) with substantial (18-48 in) spacing in between18 m (59 ft) Tow speed: 3-3.5 kts Tow duration: Experimental tows - 0.75-6.5 hrs; Depth: 66-154 m (217-505 ft) Marport headrope and wing sounders, 40 kHz	Not systematic: Experimental tows ranges 40-90 tows per year

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
					Mid-water Trawl	Net type: Various Commercial mid-water trawls Net size: Operating net width 75-136 m, height 10-20 m, with size highly dependent on vessel power. Very large meshes (128-64 m) forward tapering gradually to 4 inch in aft sections Tow speed: 3-3.5 kts Tow duration: Experimental tows - 0.75-3 hrs; Depth: 66-154 m (217-505 ft)	See above
					High frequency net imaging	DIDSON unit 31 cm x 17 cm x 14 cm, 12 MHz	
					Net camera	Camera and housing - The device is 20 in x 9 in x 4.5 in and is a complete integrated unit with internal LED light and battery. This is typically deployed on fishing gear by clipping it to the gear.	Variable,, ranging 10-20 tows per seasons
Eastern Bering Sea Upper Continental Slope Trawl Survey Summer	The goals of the study are to locate and successfully trawl stratified random locations on a variety of slope habitats; describe the composition, spatial, and depth distribution, and relative abundance of groundfish and invertebrate resources; collect biological data from a variety of commercially and ecologically important species; and to collect environmental parameters.	Eastern Bering Sea, Upper Continental Slope	Summer, biennially, 30-90 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: PNE Net size: 90 ft headrope, 100 ft footrope Tow speed: 2.5 kts Tow duration: 30 min Depth: 200-1200 m Marport headrope and wing sounders, 40 kHz	200 trawls
					SIMRAD EK60 echosounder	Freq: 38 kHz	Continuous
EcoFOCI/EMA Age-1 Walleye Pollock Assessment Survey and Ecosystem Observations in the Bering Sea	This survey assesses the distribution and condition of age-1 walleye pollock immediately after the first winter; evaluates recruitment potential of emergent age-1s, a full year prior to assessment during acoustic or bottom trawl surveys. Survey determines the abundance, distribution, size structure, and survival of other key economic and ecological species in the region, and investigates the effects of climate variability on transport pathways from spawning to potential nursery locations for juveniles.	Bering Sea Shelf, Bering Sea Slope	Winter, biennially, 7-31 DAS; samples day and night	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: PNE bottom trawl with rock hopper gear and fitted with a 1.25 cm (0.5 in) codend liner Net size: 90 ft headrope, 100 ft footrope Tow speed: between 3 and 5 kts Tow duration: 20 min Depth: Between 197 and 647 m Marport headrope and wing sounders, 40 kHz	50 bottom trawls
					Mid-water Trawl	Net type: Anchovy trawl (12m x 12m) Net size: 3 mm cod end liner Tow speed: 2-3 kts Tow duration: depth-dependent Depth: oblique to bottom (<200 m)	50 mid-water trawls
					Bongo Net	Net type: Plankton net Net size: 20 cm and 60 cm Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	50 tows with each net

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
EcoFOCI/EMA Ecosystem Observations	This plankton research is focused on how climate variability in Bering sea affects the habitat and habitat utilization by marine mammal species including endangered species (e.g., bowhead whales). A secondary objective is to develop an understanding of the resident fin and shellfish communities in the Arctic, in particular their early life histories and how they might be impacted by loss of sea ice. In addition, physical and biological data are collected. This research does not directly take marine mammals.	Bering Sea Shelf, Bering Sea Slope	Fall, spring, seasonally, annually, 7-31 DAS; samples day and night	Large chartered fishing vessel	Bongo Net	Net type: Plankton Net size: 20 cm and 60 cm Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	75 tows with each net
					Neuston Net	Net type: Plankton Net size: .25 m^2 Tow speed: 1 - 3 kts Tow duration: 10 min Depth: surface	150 tows
EcoFOCI/EMA Young-of-the-Year Walleye Pollock Assessment Survey and Ecosystem Observations in the Bering Sea	Research is critical to understanding how environmental variability and change affects abundance, distribution, and recruitment of commercially and ecologically important juvenile fishes. Provides an assessment of abundance and condition of age-0 walleye pollock prior to the onset of the first winter. Physical and biological data are collected and ecosystem observations are made.	Bering Sea	Fall, biennially, 55 DAS; samples day and night	Large chartered fishing vessel	Mid-water Trawl	Net type: Anchovy trawl Net size: 3 mm cod end liner Tow speed: 2-3 kts Tow duration: depth dependent Depth: oblique to bottom (<200 m)	50-75 trawls
					Beam Trawl	Net type: Beam trawl Net size: 7 mm mesh, 4 mm cod end liner Tow speed: 1 - 2 kts Tow duration: 10 min Depth: 50-200 m	50-75 trawls
					Bongo Net	Net type: Plankton Net size: 20 cm and 60 cm Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0-300 m	150 tows with each net
Pollock Winter Acoustic Trawl Survey - Bogoslof Island	The objective of the survey is to estimate the mid-water abundance and distribution of walleye pollock in the Bogoslof Island region. Acoustic data are collected along a series of parallel transects with a scientific echosounder. Five split-beam transducers (18, 38, 70, 120, and 200 kHz) are mounted on the vessel. Whenever sufficient echosign is encountered, trawl sampling is conducted to identify ensonified targets. Net sounders are used to position the trawl in the water column and monitor the catch taken. Physical oceanographic measurements are made throughout the cruise.	Aleutian Islands - Bogoslof Island region in the southeastern Aleutian Basin	Winter, biennially, 7-31 DAS; samples day and night	NOAA ship R/V *Oscar Dyson*	Bottom trawl with net sounders	Net type: PNE, as described above Tow speed: 3 kts Tow duration: variable Depth: 50-600 m Marport headrope and wing sounders, 40 kHz	10 trawls
					Mid-water trawl with net sounders	Net type: AWT, as described above Tow speed: 3 kts Tow duration: 10 min - 1 hr Depth: 50-600 m Simrad ITI door sensors, 40 kHz Simrad FS70 3rd wire, 200 and 333 kHz	10 trawls
					SIMRAD EK60 Echosounder with five split-beam transducers	Freq: 18, 38, 70, 120, and 200 kHz	Continuous
					CTD	Seabird 911	20 casts

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Yukon Delta Nearshore Surveys	Collecting juvenile salmon in delta habitats for energetics and diets.	Yukon Delta	May-August, annually, 20-24 DAS plus 75 field days for shore-based work; daytime sampling only	Small boats	Push Trawls	Mesh size: 6 mm Net size: 5 x 7 x 15 ft Tow speed: 3 kts Tow duration: 20 min Depth: 5-7 ft	50 trawls
					Pelagic Trawls	Mesh size: 6 mm Net size: 5 ft x 7 ft x 15 ft Tow speed: 3 kts Tow duration: 20 min Depth: 5-7 ft	150 trawls
					Kodiak Trawls	Mesh size: 6 mm Net size: 3 m x 4 m x 8 m Tow speed: 3 kts Tow duration: 15 min Depth: 12 ft	50 trawls
					Ring net	Mesh size: 6 mm Net size: 6 x 21 ft Depth: 30 ft	50 casts
Surveys Using Longline Gear							
Alaska Longline Survey *(see also effort conducted in the GOARA)*	See above-Gulf of Alaska	Gulf of Alaska, Aleutian Islands, Bering Sea Slope	Summer, fall, alternates annually between GOA and BSAI, 30-90 DAS; daytime sampling only	Large chartered fishing vessel	Longline	Mainline length: 16 km Set Depth: bottom Gangion length: 1.5 m Gangion spacing: 2 m Hook size and type: 13/0 circle # of hooks and bait: 7,200 hooks baited with squid Soak time: 3 hrs (haul-back takes up to 8 hrs)	75 stations
Projects Using Other Gears							
Acoustic Research and Mapping to Characterize EFH (FISHPAC) *(see also effort conducted in the GOARA and CSBSRA)*	This study collects acoustic and other environmental data in trawl survey areas to develop numerical habitat models for groundfish and shellfish. Bathymetric data are also collected for nautical chart updates.	Aleutian Islands, Bering Sea Shelf, Northern Bering Sea	Summer, triennially (rotate among three research areas), 21-25 DAS	NOAA ship R/V *Fairweather*	Scientific Single Beam and Multibeam Ecoshounders; Side-scan Sonar	Frequencies used: Single beam echosounder (38 kHz); multi-beam ecohosounders (50, 100 kHz); Side-scan sonar (180, 455 kHz)	Continuous
					SEABOSS bottom sampler	0.1 m^2 van Veen grap in frame with ~ 1 m^2 footprint; weight 295 kg; usually 2 grabs per station; depths <200 m	50 stations
					TACOS: 2-part towed camera system	0.8 m^2 combined footprint; 285 kg; usually 1 300-500 m tow per station; depths <200 m	20 stations
					Free-Fall Cone Penetrometer	Dropped from stationary or underway vessel to seafloor with < 3 m penetration. Cross-sectional area = 0.004 m^2; weight in air 49.7 kg.	92 stations

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Deep Sea Coral and Sponge Distribution *(see also effort conducted in the GOARA)*	See above-Gulf of Alaska	Gulf of Alaska, Aleutian Islands, Inland Southeastern Alaska	Spring, summer, fall, annually, intermittent, 30 DAS; daytime sampling only	Large chartered fishing vessel	Camera system	Stereo camera sled with two cameras four strobe lights contained in an Aluminum frame. Designed to be drifted or towed along the seafloor at a distance of ~ 1 m off the seafloor. Tow duration: 15 min	300 tows
EcoFOCI/EMA Larval Walleye Pollock Assessment Survey and Ecosystem Observations in the Bering Sea	This survey in the Bering Sea is a joint effort on behalf of EMA and EcoFOCI to assesses the abundance, distribution, size structure, and survival of larvae of key economic and ecological species (walleye pollock, Pacific cod, rock sole, yellowfin sole, flathead sole, arrowtooth flounder), and investigates the effects of climate variability on the mechanisms leading to recruitment including transport pathways from spawning to potential nursery locations.	Bering Sea Shelf, Bering Sea Slope	Spring, biennially, 7-31 DAS; samples day and night	Large chartered fishing vessel	Bongo Net	Net type: Plankton net Net size: 20 cm and 60 cm diameter Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	150 tows with each net
					Multiple-Opening and Closing Net	Net type: Plankton Net size: 1 m^2 Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 60 min Depth: 0 - 1000 m	30 tows
					Neuston Net	Net type: Plankton Net size: 0.25 m^2 Tow speed: 1.5 - 2.5 kts Tow duration: 10 min Depth: surface	150 tows
CHUKCHI SEA/BEAUFORT SEA RESEARCH AREA (CSBSRA)							
Surveys Using Trawl Gear							
Arctic Coastal Ecosystem Surveys (ACES)	Fish utilization of nearshore habitats (coastal and lagoons) and their health.	Barrow area, Beaufort and Chukchi sea coasts	Summer, 20 DAS; daytime sampling only	Small boat	Beach seine	Net size: 37 x 5 m Mesh size: 3.2 mm Set duration: 10 min round haul	50 sets
					Bottom trawl	Net type: PSBT Net size: 5 x 2.5 x 1.2 m Tow speed: 3 kts Tow duration: 30 min Depth: <20 m	24 trawls
					Mid-water trawl	Net type: Modified Maranovich Net size: 5 x 2.5 x 1.2 m Tow speed: 3 kts Tow duration: 30 min Depth: <10 m	24 per year
Arctic Ecosystem Integrated Survey *(see also effort conducted in the BSAIRA)*	See above - Bering Sea	Northern Bering Sea, Chukchi Sea - from 60°N to 72°N and from nearshore (20 m depth) to near the Russia/US border	Summer, fall, annually, 50 DAS; daytime sampling only	Large chartered fishing vessel	Surface trawl also deployed as mid-water trawl	Net type: Cantrawl or similar small mid-water trawl Net size: 55 m width, 25 m depth Tow speed: 3.5 - 5 kts Tow duration: 30 min Depth: surface to 25 m	70 trawls
					Bongo net	Net type: Bongo zooplankton Net size: 505 µm and 143 µm Tow speed: 1 m/sec Tow duration: depends on depth Depth: surface to 1 m off bottom	55 tows

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
					SIMRAD EK60 echosounder	Freq: 38 kHz	Continuous
Chukchi Sea Bottom Trawl Survey	The primary objective of the Chukchi Sea bottom trawl surveys is to collect baseline data to monitor the distribution, abundance, and general ecology of marine animals living on or near the seafloor to determine the effects of climate change and potential impacts from further industrialization.	Chukchi Sea	Summer; 1976, 1990, 2012, 2013, and intermittent in the future, 30 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: 83-112 Eastern otter trawl Net size: 83 ft headrope, 112 ft footrope Tow speed: 3 kts Tow duration: 15 min Depth: 10 - 100 m Marport headrope and wing sounders, 40 kHz	143 trawls
					Bottom Trawl	Net type: 3 m PSBT Net size: 3 m wide Tow speed: 1.5 kts Tow duration: 3 min Depth: 10 - 100 m	40 trawls
EcoFOCI Arctic Ecosystem Observations	This plankton research is focused on how climate variability in the Arctic affects the habitat and habitat utilization by marine mammal species including endangered species (e.g., bowhead whales). A secondary objective is to develop an understanding of the resident fin and shellfish communities in the Arctic, in particular their early life histories and how they might be impacted by loss of sea ice. In addition, physical and biological data are collected. This research does not directly take marine mammals.	Chukchi Sea	Summer, annually, 17 DAS; samples day and night	Large chartered fishing vessel	Bongo Net	Net type: Plankton Net size: 20 cm and 60 cm diameter Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	100 tows (20 cm bongo net) 100 tows (60 cm bongo net)
					Multiple-Opening and Closing Net	Net type: Plankton Net size: 1 m^2 Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	200 tows
					Neuston Net	Net type: Plankton Net size: 0.25 m^2 Tow speed: 1 - 3 kts Tow duration: 10 min Depth: surface	100 tows
Projects Using Other Gears							
Acoustic Research and Mapping to Characterize EFH (FISHPAC) ***(see also effort conducted in the GOARA and BSAIRA)***	This study collects acoustic and other environmental data in trawl survey areas to develop numerical habitat models for groundfish and shellfish. Bathymetric data are also collected for nautical chart updates.	Chukchi Sea	Summer, triennially (rotate among three research areas), 21-25 DAS; samples day and night	NOAA ship R/V *Fairweather*	Scientific Single Beam and Multibeam Ecoshounders; Side-scan Sonar	Frequencies used: Single beam echosounder (38 kHz); multi-beam ecohosounders (50, 100 kHz); Side-scan sonar (180, 455 kHz)	Continuous
					SEABOSS bottom sampler	0.1 m^2 van Veen grap in frame with ~ 1 m^2 footprint; weight 295 kg; usually 2 grabs per station; depths <200 m	50 stations
					TACOS: 2-part towed camera system	0.8 m^2 combined footprint; 285 kg; usually 1 300-500 m tow per station; depths <200 m	20 stations
					Free-Fall Cone Penetrometer	Dropped from stationary or underway vessel to seafloor with < 3 m penetration. Cross-sectional area = 0.004 m^2; weight in air 49.7 kg.	92 stations

2.1.2 Proposed AFSC Research Activities

Table 2 summarizes future research proposed by the AFSC. Factors that determine which research is actually carried out include scientific and management needs of the North Pacific Fisheries Management Council, NOAA, and other government priorities; the development of new technology; funding; vessel, and principal investigators availability; and if access to research areas is restricted by climate, ice, or other seasonal weather phenomena. These activities are considered part of this action, and effects from these proposed activities are analyzed in this opinion.

Table 2. Summary of new proposed AFSC fisheries research surveys and projects. These surveys and projects are in addition to those described in Table 1. Colors used in Table 2 correspond to the Research Area shading in Figure 1. Units of measurement are presented in the format data was collected. Abbreviations used in the table are the same as those in Table 1.

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Annual Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
GULF OF ALASKA RESEARCH AREA							
Projects Using Trawl Gear							
Gulf of Alaska Assessment	Identify & quantify major ecosystem processes for key groundfish and salmon species in Gulf of Alaska (GOA). Concentration on predatory & commercially important species.	Gulf of Alaska, along the shelf, slope, and basin waters of the GOA in southeast Alaska.	July, annually 24 DAS; samples day and night	Large chartered fishing vessel	Surface trawl	Net type: Cantrawl Net size: 55 m width, 25 m depth Tow speed: 3.5 to 5 kts Tow duration: 30 min Depth: surface to 25 m depth	80 trawls
					Bongo Net	Net type: bongo net Net size: 20 and 60 cm diameter Tow speed: 2 kts Tow duration: 15 min Depth: 1-200 m	80 tows
					CTD with rosette water sampler	Tow speed: 0 kts Tow duration and depth: variable	80 casts
Ongoing Rockfish Biological Sampling and Sampling Theory Research *(See also effort in the BSAIRA)*	Rockfish biological, movement, and distributional data is still limited in Alaska. Several previous studies have investigating alternative sampling designs to improve precision of biomass estimates. Our purpose is to potentially investigate new sampling designs, improve rockfish maturity estimates, and study underwater tagging methods.	Gulf of Alaska and Aleutian Islands	Summer, spring, 7-31 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: PNE, Tow speed: 3-3.5 kts Tow duration: 15-30 min Depth: 50-250 m Marport headrope and wing sounders, 40 kHz	30 trawls in GOARA
Pollock Summer Acoustic Trawl Survey - Gulf of Alaska *(includes additional camera gear from Status Quo)*	New camera work: We will build a prototype and up to 9 replicate low-cost 'camera traps', to unobtrusively determine the distribution of fish in relation to the seafloor. Replicate units are essential to provide adequate target densities and spatial coverage. Stereo-camera methods would be used to quantitatively determine the distribution of fishes relative to the seafloor during acoustic surveys.	Gulf of Alaska shelf/slope from approximately 50 m bottom depth out to 1000 m bottom depth between the Islands of Four Mountains and Yakutat Trough.	Summer, biennially, 60 DAS; daytime trawl sampling only but other listed work occurs at night	Large chartered fishing vessel	Bottom trawl, mid-water trawl, small mid-water trawl, and sonars		20 bottom trawls, 100 mid-water trawls, 10 small mid-water trawls
					Camera traps	Each unit will consist of paired consumer grade still cameras and strobe lights mounted on a robust frame (crab pot) lying on the seafloor. The camera will be triggered using an infra-red detector that will fire the cameras when a fish moves into the range of the camera lens.	Up to 10 deployments

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Annual Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Using Trawl Cameras instead of Bottom Trawls to Estimate Fish Abundance in the Gulf of Alaska and Aleutian Islands *(See also effort in the BSAIRA)*	To minimize damage to the seafloor and extraction of fishes new methods need to be developed to assess fish abundance in Alaska. One potential method would be the use of cameras to determine fish abundance rather than traditional bottom trawls. This study will use cameras mounted inside bottom trawls to estimate abundance of groundfish species. A series of camera trawls will be conducted and compared to side-by-side bottom trawl catches to detect significant differences in catch rates, length, and species compositions between the two.	Gulf of Alaska and Aleutian Islands	Summer, 1-7 DAS; samples day and night	Large chartered fishing vessel	Bottom trawls with and without video cameras	Net type: PNE (as previously described) Tow speed:3-3.5 kts Tow duration:15-30 min Depth:50-200 m Marport headrope and wing sounders, 40 kHz Camera and housing - The device is 20 in x 9 in x 4.5 in and is a complete integrated unit with internal LED light and battery. This is typically deployed on fishing gear by clipping it to the gear.	40 trawls total (20 replicate sites with 2 trawls per site)
Projects Using Longline Gear							
Deep Water Groundfish Surveys	This is a possible survey that will collect biological information on deep water species such as grenadiers for use in stock assessments. This is a possible survey that will take place in the future. It is likely that a random or systematic design will be used to observe deep water species with an Autonomous Underwater Vehicle or capture them with longlines.	Gulf of Alaska, Inland Southeastern Alaska	Summer, biennially, 7-31 DAS; daytime sampling only	Large chartered fishing vessel	Bottom longline gear	Mainline length: 16 km Set Depth: bottom Gangion length: 1.5 m Gangion spacing: 2 m Hook size and type: 13/0 circle # of hooks and bait: 7,200 hooks baited with squid Soak time: 3 hrs	20 sites
Projects Using Other Gears							
Acoustic Assessment of Rockfish in Untrawlable Areas	We will generate rockfish density estimates in untrawlable (and trawlable) areas in the GOA to assess the potential impact that these estimates can have on stock assessment efforts. An acoustic-camera survey method will be used to provide abundance estimates for the dominant rockfish species in untrawlable and trawlable habitats. The survey data will be collected in both habitats throughout much of the central and western GOA.	Central and Western Gulf of Alaska	Summer, biennially, 30-90 DAS; samples day and night	Large chartered fishing vessel	SIMRAD EK60 echosounder	Freq: 38 kHz	Continuous during sampling
					Camera system	The electronic components of the drop cameras are housed in a (1 m x 0.75 m x 0.5 m) cage constructed from aluminum tubing. Two machine-vision cameras spaced approximately 3- cm apart in underwater housings are connected via ethernet cables to a computer also in an underwater housing within the cage	Up to 100 camera drops per survey
					CTD	Tow speed: 0 Duration: 5-15 min	100 casts
Crab Studies in Kodiak Island Area	Researchers at the Kodiak Laboratory would conduct small scale studies and collections in the nearshore Kodiak Archipelago to support studies and outreach on crab biology, ecology, movement, and culturing.	Central Gulf of Alaska, Kodiak Archipelago	All seasons, monthly; daytime sampling only	Skiffs or small vessel	Pot	Crab pots of various sizes constructed of rebar and webbing Bait: fish or squid Soak time: up to 3 days	25 sets
					Diving	SCUBA/Snorkeling	25 collections

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Annual Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
					Beach Seine	Net type: Seine Net size: 61 m x 5 m Mesh size: 3.2 mm Set duration: 10 min	10 sets
					Beam Trawl	Net type: Beam trawl Net size: 3 m x 15 m Mesh size: 2-7 cm Tow speed: <1 kts Tow duration: 10 min	20 sets
***Primnoa* Distribution, Recovery and Genetic Connectivity in the Gulf of Alaska**	*Primnoa* corals are an important habitat feature in the Gulf of Alaska. The purpose of this project is to map thickets of *Primnoa*, use in situ measurements to examine growth and recovery rates for the species, and collect samples for genetic connectivity among north Pacific populations of *Primnoa*.	Gulf of Alaska - Offshore shelf, offshore slope	Summer, 7-31 DAS; daytime sampling only	Large chartered fishing vessel	Towed camera vehicle	Still cameras w/strobe lighting, Towing speed: 5 kts	10 transects at 4-6 sites
					Simrad EK 60Echosounders	38 and 120 kHz	Continuous
					CTD Profiler	Duration: 5-15 min	5-20 casts
Reproductive Ecology of Red Tree Coral	Study will involve periodic sampling of individually tagged red tree coral colonies at depths between 10 and 30 m.	Gulf of Alaska	Winter, annually, 1-7 DAS; daytime sampling only	Motorized skiff	SCUBA divers	Sampling depth: 10-30 m	1 site
Response of Fish to Drop Camera Systems	This project will describe the behavioral response of fishes to a drop camera during deployments to estimate fish density and length.	Gulf of Alaska - Offshore shelf	Summer, 1-7 DAS; samples day and night	Large chartered fishing vessel	SIMRAD EK60 echosounder	Freq: 38 kHz	Continuous
					Camera	The electronic components of the drop cameras are housed in a (1 m x 0.75 m x 0.5 m) cage constructed from aluminum tubing. Two machine-vision cameras spaced approximately 3 cm apart in underwater housings are connected via ethernet cables to a computer also in an underwater housing within the cage.	~20 transects at 2 sites
					High frequency net imaging	DIDSON unit 31 cm x 17 cm x 14 cm, 12 MHz	~20 transects at 2 sites
St. John Baptist Bay Sablefish Ecology	This is an ecological study of juvenile sablefish in St. John Baptist Bay. The project aims to identify the unique features of the bay that support sablefish populations. Diet and prey fields will be documented, and basic oceanographic information will be collected.	Gulf of Alaska - St. John Baptist Bay, Chichagof Island, Southeast Alaska	Spring, summer, fall, seasonally, 1-7 DAS; daytime sampling only	Large chartered fishing vessel, Motorized skiff	Bongo net	Net type: Plankton Net size: 20 cm and 60 cm diameter Tow speed: 1.5 - 2.5 kts Tow duration: 10 - 30 min Depth: 0 - 300 m	~50 hauls per season (150 per year)
					Ring net	Mesh size: 6 mm Net size: 6 x 21 ft Depth: 30 ft	~50 casts per season (150 per year)

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Annual Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
BERING SEA/ALEUTIAN ISLANDS RESEARCH AREA							
Projects Using Trawl Gear							
Habitat, Blue King Crabs, and the Benthic Community: Comparisons within Space and Time	The study objectives are to define the essential fish habitat for blue king crabs; to determine the pattern of blue king crab larval dispersal and settlement in relation to the benthic habitat; to determine the distribution and habitat specific densities of all benthic life history stages of blue king crab; to examine the habitat-specific composition of the benthic assemblages; to identify blue king crab predators and understand trophic linkages; and to compare results from this study between the Pribilof Islands and St. Mathew, and with historical data.	Bering Sea Shelf - Pribilof and St. Matthew Islands	Fall, spring, seasonally, 7-31 DAS; daytime sampling only	Large chartered fishing vessel	Beam trawl	3 m PSBT Net size: 3 m wide Tow speed: 1.5 kts Tow duration: 3 min Depth: 5-40 m	200 stations (100 in each area); beam trawl or rock dredge used based on habitat data
					Rock dredge	Virginia crab style dredge fitted with a half inch nylon mesh liner Dredge size: 6 ft wide Tow: 3 kts	
Larval Supply, Juvenile Settlement, and Habitat Use by Red King Crab	This project would map both the distribution and the habitat associations of juvenile red king crabs in the Bering Sea.	Bering Sea Shelf - likely Bristol Bay and Norton Sound areas	Fall, 7-31 DAS; daytime sampling only	Large chartered fishing vessel, boat (6-20 m)	Beam trawl	3 m PSBT Net size: 3 m wide Tow speed: 1.5 kts Tow duration: 3 min Depth: 10-50 m	100-300 trawls
					Rock dredge	Dredge type: Virginia crab style dredge fitted with a half inch nylon mesh liner Dredge size: 6 ft wide Dredge size: Tow speed: 3 kts Tow duration:	~ 100 hauls
Locating Essential Spawning Grounds for Red King Crab *(additional work from Status Quo Bering Sea Shelf Bottom Trawl Survey)*	The study proposes to use pop-up satellite tags to track the gross movement of oviparous females and to locate the precise location of larval release. This, in turn, will help to identify what areas represent important spawning areas, by implication habitats, and thus help managers decide on the trawl closure areas. The gross movement of the female crabs will also help us understand movement patterns of red king crab in Bristol Bay and will provide important estimates of natural mortality rates for females during the inter-molt period. This study will take place during the Bering Sea Shelf Bottom Trawl Survey.	Bering Sea Shelf	Summer, 30-90 DAS; daytime sampling only	Large chartered fishing vessel	Specimens collected during Bering Sea Shelf Bottom Trawl Survey	Net type: 83-112 Eastern otter trawl Net size: 83 ft headrope, 112 ft footrope Tow speed: 3 kts Tow duration: 30 min Depth: 20 to 200 m	Up to 10 tows (60 crabs tagged)
Northern Bering Sea Bottom Trawl Survey	The AFSC RACE Division conducts the NBS (northern Bering Sea) shelf bottom trawl survey on a triennial basis. The NBS has no large-scale commercial fisheries; however, climate change and the impacts of industrialization are a concern because of their potential to fundamentally alter the biological community thereby impacting fishes, crabs, marine mammals, and the subsistence fisheries of western Alaska fishing	The NBS area is bounded by the shelf break and the U.S.-Russian Convention Line in the west, the Bering Strait in the north, and Norton Sound in the east. The southern boundary is adjacent to the	Summer, biennially, 45 DAS; daytime sampling only	Large chartered fishing vessel, motorized skiff	Bottom trawl with net sounders	Net type: 83-112 Eastern otter trawl Net size: 83 ft headrope, 112 ft footrope Tow speed: 3 kts Tow duration: 30 min Depth: 20 to 200 m Marport headrope and wing sounders, 40 kHz	160 trawls

Research Activity Name	Survey Description	General Area of Operation	Season, Frequency, Annual Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
	communities. The primary objective of the NBS bottom trawl surveys is to collect baseline data to monitor the distribution, abundance, and general ecology of marine animals living on or near the seafloor to determine the effects of climate change and potential impacts from further industrialization.	northern boundary of the EBS Bottom Trawl Survey			CTD	Tow speed: 0 Duration: 5-15 min	160 samples
					Simrad ES60 echosounders	Freq: 38 kHz and 120 kHz.	Continuous
Ongoing Rockfish Biological Sampling and Sampling Theory Research *(See also effort in the GOARA)*	See description above in GOARA	Gulf of Alaska and Aleutian Islands	Summer, spring, 7-31 DAS; daytime sampling only	Large chartered fishing vessel	Bottom trawl with net sounders	Net type: PNE, as described above, and yet to be determined prototype alternate designs (of similar dimensions) Tow speed: 3-3.5 kts Tow duration: 15-30 min Depth: 50-250 m Marport headrope and wing sounders, 40 kHz	30 trawls in BSAIRA
Pollock Summer Acoustic Trawl Survey - Bering Sea *(includes additional camera gear from Status Quo)*	New camera work: We will build a prototype and up to 9 replicate low-cost 'camera traps', to unobtrusively determine the distribution of fish in relation to the seafloor. Replicate units are essential to provide adequate target densities and spatial coverage. Stereo-camera methods would be used to quantitatively determine the distribution of fishes relative to the seafloor during acoustic surveys.	Eastern Bering Sea shelf/slope from the Aleutian peninsula to the U.S.-Russian Convention Line	Summer, biennially, 62 DAS; daytime sampling only	NOAA ship R/V *Oscar Dyson*	Bottom trawl, mid-water trawl, sonar gear		15 bottom trawls, 100 mid-water trawls
					Camera traps	Each unit will consist of paired consumer grade still cameras and strobe lights mounted on a robust frame (crab pot) lying on the seafloor. The camera will be triggered using an inexpensive infra-red detector that will fire the cameras when a fish moves into the range of the camera lens.	Up to 10 deployments
Using Trawl Cameras instead of Bottom Trawls to Estimate Fish Abundance in the Gulf of Alaska and Aleutian Islands *(See also effort in the GOARA)*	See description above in GOARA	Gulf of Alaska and Aleutian Islands	Summer, 1-7 DAS; samples day and night	Large chartered fishing vessel	Bottom trawls with and without video cameras	Net type: PNE (as previously described) Net size: Tow speed:3-3.5 kts Tow duration:15-30 min Depth:50-200 m Marport headrope and wing sounders, 40 kHz Camera and housing - The device is 20 in x 9 in x 4.5 in and is a complete integrated unit with internal LED light and battery. This is typically deployed on fishing gear by clipping it to the gear.	40 trawls total (20 replicate sites with 2 trawls per site)
Projects Using Other Gear							
The Distribution and Habitat Association of Juvenile *Chionoecetes* crab	This study is a survey of suspected juvenile Tanner and snow crab habitat and distribution in Bering Sea. We would use a camera mounted on a benthic scrap to both identify the habitat and capture juveniles.	Bering Sea Shelf	Summer, fall; 2017, 2018	Large chartered fishing vessel	Bottom sled with camera	Design to be determined (see http://doc.nprb.org/web/research/research%20pubs/615_habitat_mapping_workshop/Individual%20Chapters%20High-Res/Ch7%20Rooper.pdf)	Expectation: 10-20 tows (capture up to 400 juvenile crabs)

2.1.3 IPHC Research Activities

Table 3 summarizes research conducted by the IPHC in the GOARA and BSAIRA. IPHC does not conduct research inside the CSBSRA. Most research activities occur in both the GOARA and the BSAIRA, so activities are not divided by area in Table 3 as they were for AFSC activities in Table 1 and Table 2. Table 3 summarizes the IPHC research programs as they have occurred in the recent past (2012–2016), in addition to new research programs with planned funding.

IPHC research programs include the following:

- IPHC Fishery-independent Setline Survey (IPHC Survey)
- Gonad Collection
- IPHC Aboard AFSC Groundfish Trawl Surveys
- Commercial Fishery Port Sampling
- Ongoing Research Projects
- New Research Projects

With the exceptions of the IPHC survey and gonad collection, the IPHC uses existing surveys and fisheries to collect data for their research. Any effects to marine mammals are analyzed with regard to the main survey effort – either the IPHC setline survey itself, or other AFSC research activities analyzed in this opinion. For example, the IPHC uses existing AFSC groundfish trawl surveys to collect information on small Pacific halibut that are not yet vulnerable to the gear used for the IPHC survey or commercial fishery, and as an additional data source and verification tool for stock analysis. This survey is led and conducted by AFSC, and the effects from these surveys are analyzed in this opinion as part of those research activities conducted by the AFSC. The port sampling programs are sampling commercial fisheries catch, which is covered under a Biological Opinion for the commercial groundfish fisheries in Alaska (NMFS 2010a), and is not analyzed in this opinion. The rest of the research projects occur in conjunction with the IPHC survey described below.

IPHC Fishery-Independent Setline Survey (the IPHC survey)

The IPHC survey is consistently conducted every year from May- September in waters 400 fm (732m) or shallower, but the exact location of survey effort may vary year to year within the same general area. This survey provides data for the Pacific halibut stock assessment. Catch per unit effort (CPUE) in numbers and weight, size, age, and sex composition of the Pacific halibut catch are used to monitor changes in abundance, growth, and mortality in the adult population. Survey data are used to determine Pacific halibut range, local depletion, and fleet distribution effects on the resource. All cases of suspected interaction between marine mammals and fishing gear are recorded to monitor occurrences and to help assess whether marine mammal depredation affects that set’s data to the extent that it cannot be used in the Pacific halibut stock assessment. Additionally, marine mammal sightings are reported to the National Marine Mammal Laboratory using their Protected Species Interaction Form.

Gonad Project

A one-time special project is planned to collect gonads for full characterization of the annual reproductive cycle in male and female Pacific halibut. In order to characterize the full cycle of gonad maturation for Pacific halibut, IPHC will collect 100 samples per month by fishing with longline gear on 80' vessels at regular (monthly) intervals throughout a full year, including outside of IPHC survey seasons, in the GOARA and BSAIRA. Gonad collection may extend into deeper waters than the IPHC survey in the winter months, when Pacific halibut congregate in water that may be deeper than 400 fm (732m).

Future Research

Within the next five years, the IPHC plans to extend its survey grid northward to just south of East Foreland in Cook Inlet for a single year. This extension overlaps with Cook Inlet beluga critical habitat and is analyzed in the exposure analysis of this opinion.

Table 3. Summary of IPHC research activities in the GOARA and BSAIRA. Most research projects occur in both the GOARA and the BSAIRA, so we do not distinguish by areas (in colors) as we did in Tables 1 and 2.

Research Activity Name	Survey Description	General Area of Operation	Season; Frequency; Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
IPHC Fishery-independent Setline Survey (occurs annually)	This survey provides data feeding into the Pacific halibut stock assessment. Catch per unit effort (CPUE) in numbers and weight, size, age, and sex composition of the Pacific halibut catch are used to monitor changes in abundance, growth, and mortality in the adult population. Survey data are used to determine halibut range, local depletion, and fleet distribution effects on the resource. In addition to halibut data, samplers record catch of other organisms captured incidentally to the gear targeting Pacific halibut. These data provide insight into bait competition, rate of bait attacks, and bycatch quantity for the commercial halibut fishery. This survey also collects oceanographic data using water column profilers at each setline station. The profilers collect a suite of oceanographic data from surface to bottom, including pressure (depth), conductivity (salinity), temperature, dissolved oxygen, pH, and fluorescence (chlorophyll *a* concentration).	From southern Oregon to the island of Attu in the Aleutian Islands, and north along and including the Bering Sea continental shelf. Survey stations are laid out on a 10 by 10 nautical mile (nm) grid within the 20 -275 fathom (fm) depth range for most years, and may extend to 400 fm or as shallow as 10 fm in areas that do not have sufficient habitat in the 20fm-275fm depth range.	Annual. The duration is from late May to the beginning of September. Between 2012 and 2016 there was a yearly average of 397 days at sea split among the 11-15 boats chartered to conduct the survey.	Chartered commercial longline vessels ranging in length from 50 ft to 120 ft., but generally 80 ft or less.	Fixed-hook demersal longline gear	Gear consists of 1,800 feet long (300 fathoms) skates, with 100 hooks per skate. Three to ten skates may be fished at a station (this equates to a total longline length ranging from 5,400 to 18,000 feet [1.65 to 4.5 km]). Skates are uniformly rigged with circle hooks (16/0 Mustad or equivalent) in average or better condition spaced along the groundline at 18-foot intervals (100 per skate). Gangions are 72-thread count, hard lay material between 24 to 48 inches after tying. Swivels may not be used. Hooks are baited with 0.25 lb chum salmon (Oncorhynchus keta). Setting may not commence before 5 hours to ensure daylight. Gear must soak for 5 hours before being retrieved.	1,300 survey stations are projected for 2017. Subsequent years are projected to range between 1,100 and 1,235 stations, and will not exceed 1,500 stations within the 5-year time frame.
					Water column profiler	Seabird SBE19plusV2 CTD sensor, with additional chlorophyll, dissolved oxygen, and pH sensors	1 cast at each survey station immediately prior to retrieving the longline, conditions permitting
IPHC aboard AFSC groundfish trawl surveys in the Gulf of Alaska, Bering Sea, and Aleutian Islands ***(Occurs onboard AFSC chartered vessels)***	The IPHC uses NMFS trawl surveys to collect information on small Pacific halibut that are not yet vulnerable to the gear used for the IPHC Fishery-independent Setline Survey or commercial fishery, and as an additional data source and verification tool for stock analysis.	Eastern Bering Sea continental shelf and within the 200-m depth contour.	Summer (typically 28 May to 3 August)	F/V *Vesteraalen*; F/V *Alaska Knight*; F/V *Aldebaran;* F/V *Sea Storm*; F/V *Ocean Explorer*; Or equivalent fishing vessel	Bottom trawl	83-112 Eastern trawl with a 25.3 m headrope and 34.1 m footrope; or Poly Nor'Eastern survey trawl with 27.2 m headrope and 36.75 m footrope	Approximately 376 survey stations
Commercial fishery port sampling program ***(Using existing commercial catch)***	IPHC staff samples commercial catch for Pacific halibut and collects otoliths, fork lengths, logbook information, and final landing weights.	Alaska, British Columbia, Washington, and Oregon.	Approximately 19 March through 7 November	Various commercial fishing vessels	Setline	Variable	Varies by year
ONGOING RESEARCH PROJECTS							
Voluntary at-sea sex marking and portside sampling of commercial longline vessels	This is part of a suite of integrated studies ultimately designed to obtain reliable sex data from eviscerated commercial landings.	Commercial vessels throughout Alaska, British Columbia, and US West Coast	Variable	Various commercial fishing vessels	Gutting knife	For females, two cuts made in the dorsal (upper) fin; for males, a single cut through the white-side gill plate.	Varies by year; 330 sex-marked samples were taken in 2016.

Research Activity Name	Survey Description	General Area of Operation	Season; Frequency; Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Genetic sexing techniques for Pacific halibut	This work will allow direct and reliable monitoring of sex ratios within commercial catch. Recent sensitivity analyses have indicated that uncertainty regarding sex ratios within commercial harvest may be the most influential factor affecting the understanding of female spawning stock biomass, with 10% variance in estimated sex ratios translating into a roughly 50 million pound range in estimates of such biomass. There is no reliable way to determine sex at landing because all Pacific halibut are eviscerated at sea. The current work will develop genetic assays that will allow for the rapid and cost-effective sex identification of large samples from the commercial Pacific halibut fishery at relatively low cost.	Genetic samples were collected between 2003 and 2007 concurrently with the IPHC fishery-independent setline surveys.					Approximately 828 individual fish were retained for genetic sampling.
Assessment of mercury and other contaminants in Pacific halibut	Work with ADEC to better characterize the levels of contaminants found in Alaska-caught Pacific halibut. Halibut flesh (muscle and liver) samples are collected from the IPHC Fishery-independent Setline Survey.	Occurs concurrently with the IPHC Fishery-independent Setline Survey.					Varies by year; 219 samples were collected in 2016
Pop-up Archival Transmitting (PAT) tagging studies	The IPHC has been conducting PAT tagging in the Bering Sea and Aleutian Islands to investigate seasonal and inter-annual dispersal. PAT tags are attached to the fish and are programmed to release and float to the surface at 365 days after tagging. When the tag reaches the surface, it begins transmitting data to the NOAA polar-orbiting satellites, administered by the Advanced Research and Global Observation System (ARGOS). These tags summarize temperature and depth data, depth-temperature profiles, and light-based geoposition estimates. Halibut from different survey stations within the IPHC study area are tagged and released typically every year.	Occurs concurrently with the IPHC Fishery-independent Setline Survey.			PAT tags	Mk10 PAT tag (manufactured by Wildlife Computers, Redmond, WA); Approximately 2 cm (0.75 in) in diameter , 17 cm (6.5 in) in length, with a 12-cm (5-in) antenna made of plastic-coated braided cable; Attached via dart and leader assembly with an 18-cm (7-in) leader of monofilament line covered in black adhesive-lined shrink tubing secured to the fish using a titanium dart embedded through the pterygiophores; Leader is attached to the tag body via thin metal wire through which an electrical current is induced that causes the metal to rapidly corrode on the programmed date.	Varies by year; total of 55 Pacific halibut were tagged in 2016 (20 in the 4D Edge North region and 35 in the Bering Sea).
Archival tags: tag attachment protocols	Recovery rates of archival tags affixed to Pacific halibut using four different external mounting protocols are used to test in a field release of dummy archival tags.	Fish were tagged off northern Kodiak Island (Area 3A)	Occurs concurrently with the IPHC Fishery-independent Setline Survey in the summer of 2013.		Archival tags	Three types of archival tags by Lotek Wireless: - LTD 2310 - LAT 1800cl - LAT 1800fp	900 fish were tagged in 2013; total tags recovered in 2016 were 32.
***Ichthyophonus* Incidence Monitoring**	Investigation of the protozoan parasite *Ichthyophonus* in Pacific halibut.	Occurs concurrently with the IPHC Fishery-independent Setline Survey.					Varies by year

Research Activity Name	Survey Description	General Area of Operation	Season; Frequency; Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
At-sea collection of Pacific halibut weight to reevaluate conversion factors	Collect data on IPHC's Fishery-independent Setline Survey for use in estimating the relationship between fork length and net weight, including the estimation of adjustments necessary to convert head-on weight to net weight, as well as estimation of shrinkage (potentially occurring in both length and weight) from time of capture to time of offload.	Occurs concurrently with the IPHC Fishery-independent Setline Survey.					Varies by year. Weights were recorded for 11,392 Pacific halibut in 2016.
Wire tagging of Pacific halibut on AFSC trawl and setline surveys	Investigates both seasonal and inter-annual dispersal of Pacific halibut in the Bering Sea and Aleutian Islands.	Occurs concurrently with the IPHC Fishery-independent Setline Survey and the NMFS groundfish trawl surveys.			PAT tags	Plastic-coated wire opercular tags	Varies by year. 763 U32 Pacific halibut were tagged and released in 2016.
NEW RESEARCH PROJECTS							
Full characterization of the annual reproductive cycle in adult male and female Pacific halibut ***(New study in 2017)***	This study aims to improve knowledge on basic aspects of the reproductive physiology of the Pacific halibut and to provide an updated and more comprehensive description of maturity in this species.	These new projects would occur concurrently with the IPHC fishery-independent survey.					
Investigation of Pacific halibut dispersal on Bowers Ridge via PAT tags ***(New study in 2017)***	This study is used to gain greater understanding of the timing of movements within this stock component, identifying winter spawning locations, and investigating mixing among regulatory areas in a fishery-independent manner.						
Tail pattern recognition analysis in Pacific Halibut ***(New study in 2017)***	Collect high resolution images of Pacific halibut tail patterns with the hypothesis that these patterns are unique to individual fish.						
Condition factors for tagged U32 fish ***(New study in 2017)***	Collect condition factor information opportunistically on all fish under 32 inches in length that are tagged and released.						
Identification and validation of markers for growth in Pacific halibut ***(New study in 2017)***	Identify and validate appropriate molecular markers for growth that can be used to identify the presence of distinct growth patterns in the Pacific halibut population and evaluate the influence of environmental conditions on somatic growth.						

Research Activity Name	Survey Description	General Area of Operation	Season; Frequency; Yearly Days at Sea (DAS)	Vessel Used	Gear Used	Gear Details	Number of Samples
Discard mortality rates and injury classification profile by release method ***(New study in 2017)***	Develop an injury profile for different release techniques with associated physiological condition measures, to calculate discard mortality rates on vessels carrying electronic monitoring systems rather than observers.						
Sequencing the Pacific halibut genome ***(New study in 2017)***	Generate a first draft of the genome of Pacific halibut to identify genomic regions and genes that are responsible for temporal and spatial adaptive and phenotypic characteristics. This will help better understand the genetic and evolutionary changes that occur in response to environmental and fisheries-related influences.						
GONAD COLLECTION							
Gonad collection for full characterization of the annual reproductive cycle in male and female Pacific halibut ***(One-time special project)***	In order to characterize the full cycle of gonad maturation for Pacific halibut, gonads will need to be collected at regular (monthly) intervals throughout a full year, including outside of the commercial and setline survey seasons.	Gulf of Alaska, Aleutian Island Archipelago, and the Bering Sea.	All seasons; samples collected on a monthly basis; approximately 50 total annual days at sea.	Commercial longline vessels ranging in length from 50 ft to 120 ft, but generally 80 ft or less.	Demersal longline gear	Because these will be specimen collection trips, rather than a survey, gear standardization will not be required. Gear will be that which is typically used by the commercial halibut and sablefish fleet and may be snap gear or fixed-hook longline gear. Gear differences are not expected to differentially affect marine mammals, which interact similarly with all of these commercial gears.	(100) samples per month [(50) male halibut >50 cm fork length and (50) female halibut >85 cm fork length] for (12) consecutive months. Total sample collection over the entire project involves male (600) and female (600) halibut, but sacrifice and/or retention of additional non-sampled individuals that will likely be required in order to meet the sampling objectives.

2.1.4 Potential Survey Impacts

For the purposes of analysis, the AFSC and IPHC surveys have been grouped according to their potential impacts to listed resources for reference throughout this opinion. Table 4 shows these survey groups.

Vessels transiting through marine habitat of the GOARA, BSAIRA, and CSBSRA create noise and pose the risk of vessel strike to ESA-listed species. Surveys that remove prey species in these research areas may make food less available for ESA-listed species and reduce the foraging value of areas within designated critical habitat. Surveys that use acoustic gear which emits sound within hearing range of marine mammals may cause effects to hearing in those marine mammals. A description of acoustic gear used in the research activities is presented in Table 5.

. Surveys that use trawl, gillnet, or longline gear may cause gear interactions with ESA-listed species. Finally, surveys that transit and set gear within 3nm of rookeries and haulouts may cause terrestrial disturbance of Steller sea lions. The interactions between these research activities and ESA-listed species will be described in more detail and evaluated in the *Exposure Analysis* (Section 6).

Table 4. Research Surveys group according to potential impacts.

Stressor	Surveys Included
Surveys conducted with vessels transiting through waters off Alaska with risk of vessel strike	All surveys listed in Tables 1-3.
Surveys removing prey species from marine habitat	• Bering Sea Shelf Bottom Trawl Survey (BSAIRA) • Aleutian Islands Biennial Shelf and Slope Bottom Trawl Groundfish Survey (BSAIRA) • Alaska Longline Survey (GOARA and BSAIRA) • Gulf of Alaska Biennial Shelf and Slope Bottom Trawl Groundfish Survey (GOARA) • ADFG Large-mesh Trawl Survey of Gulf of Alaska and Eastern Aleutian Islands (GOARA) • Conservation Engineering (various research activities GOARA and BSAIRA) • Eastern Bering Sea Upper Continental Slope Trawl Survey Summer (BSAIRA) • Conservation Engineering (various research activities, GOARA) • IPHC Fishery-independent Setline Survey (GOARA and BSAIRA)
Surveys using acoustic gear within the hearing range of ESA-listed species	Acoustic Surveys Conducted in the GOARA • Pollock Summer Acoustic Trawl Survey - Gulf of Alaska (Biennial) • Pollock Winter Acoustic Trawl Survey - Shelikof Strait • Pollock Winter Acoustic Trawl Survey – Shumagin/Sanak Islands • Gulf of Alaska Shelf and Slope Bottom Trawl Groundfish Survey (Biennial) • Acoustic Research and Mapping to Characterize EFH (FISHPAC) Acoustic Surveys Conducted in the BSAIRA • Aleutian Islands Shelf and Slope Bottom Trawl Groundfish Survey (Biennial) • Arctic Ecosystem Integrated Survey • Bering Sea Shelf Bottom Trawl Survey • Eastern Bering Sea Upper Continental Slope Trawl Survey Summer (Biennial) • Pollock Summer Acoustic Trawl Survey - Bering Sea • Pollock Winter Acoustic Trawl Survey - Bogoslof Island (Biennial)

Stressor	Surveys Included
	• Bering Aleutian Salmon International Survey (BASIS) • Acoustic Research and Mapping to Characterize EFH (FISHPAC) • Response of Fish to Drop Camera Systems • Northern Bering Sea Bottom Trawl Survey Acoustic Surveys Conducted in the CSBSRA • Arctic Ecosystem Integrated Survey • Acoustic Research and Mapping to Characterize EFH (FISHPAC)
Surveys with potential for Level A harassment (injury or mortality)	All surveys in Tables 1-3 that use trawl, gillnet, or longline gear
Surveys with potential for Level B terrestrial disturbance of Steller sea lions	All surveys in Tables 1-3 that are conducted within 3nm of Steller sea lion rookeries and haulouts.

Table 5. Output characteristics for active acoustic equipment used in AFSC research activities.

Acoustic system	Operating frequencies	Maximum source level (dB re 1 µPa at 1 m)	Single ping duration (ms) and repetition rate (Hz)	Orientation/ Directionality	Nominal beam width (degrees)
Simrad EK60 narrow beam echosounder	18, 38, 70, 120, 200 kHz	226.7	1 ms @ 1 Hz	Downward looking	11°
Simrad ME70 narrow beam echosounder	70 kHz	226.7	1 ms @ 1 Hz	Downward looking	11°
Simrad ES60 multibeam echosounder	38 and 120 kHz	226.6	1 ms @ 1 Hz	Downward looking	7°
Reson 7111 multibeam echosounder	38, 50, 100, 180, 300 kHz	230		Downward and forward looking	150°
Abbreviations: kHz = kilohertz; dB re 1 µPa at 1 m = decibels referenced at one micro Pascal at one meter; ms = millisecond; Hz = hertz					

Multibeam Echosounder

Multibeam echosounders work by transmitting acoustic pulses into the water then measuring the time required for the pulses to reflect and return to the receiver and the angle of the reflected signal. The depth and position of the reflecting surface can be determined from this information, provided that the speed of sound in water can be accurately calculated for the entire signal path. The use of multiple acoustic 'beams' allows coverage of a greater area compared to single beam sonar. The sensor arrays for multibeam echosounders are usually mounted on the keel of the vessel and have the ability to look horizontally in the water column as well as straight down. Multibeam echosounders are used for mapping seafloor bathymetry, estimating fish biomass, characterizing fish schools, and studying fish behavior. The AFSC uses the Simrad ES60 operating at 38 and 120 kHz.

Multi-Frequency Sensors

Similar to multibeam echosounders, multi-frequency split-beam sensors are deployed from NOAA survey vessels to acoustically map the distributions and estimate the abundances and biomasses of many types of fish; characterize their biotic and abiotic environments; investigate ecological linkages; and gather information about their schooling behavior, migration patterns, and avoidance reactions to the survey vessel. The use of multiple frequencies allows coverage of a broad range of marine acoustic survey activity, ranging from studies of small plankton to large fish schools in a variety of environments from shallow coastal waters to deep ocean basins. Simultaneous use of several discrete echosounder frequencies facilitates accurate estimates of the size of individual fish, and can also be used for species identification based on differences in frequency-dependent acoustic backscattering between species. The AFSC uses primarily the Simrad EK60, which is a split-beam echosounder with built-in calibration. It is specifically suited for permanent installation onboard a research vessel. The Simrad EK60s used in AFSC surveys operate in multiple frequencies simultaneously; 18, 38, 70, 120, and 200 kHz.

Other Sensors

AFSC operates several low-powered sensors such as net measurement sensors and pingers to repel or discourage marine mammals from surface trawl and gill nets. These acoustic devices were not identified in the NMFS LOA (Federal Register) as having frequency, power, or patterns of use that would expose marine mammals to Level B take.

2.1.5 Mitigation Measures

2.1.5.1 Mitigation Measures included as part of the Action

The following suite of monitoring, mitigation, reporting, and handling procedures for NMFS-managed protected species will be employed by the AFSC, AFSC-supported operations, and IPHC during all research activities. The procedures are considered part of the action analyzed in this Opinion, and they apply to all AFSC research activities regardless of whether they occur on NOAA-owned, NOAA-chartered, or on NOAA-supported vessels, including those operated by NOAA, ADFG (Large Mesh Trawl Survey), individual charter vessel owners, and the IPHC. This opinion uses the terms AFSC-supported entities, cruises, and operations to refer collectively (and interchangeably) to chartered and contract vessels supporting AFSC research. Mitigation measures are those taken to avoid and/or minimize the harassment of listed species analyzed in this Opinion. Monitoring and reporting requirements help ensure compliance with the ITS accompanying this Opinion. AFSC must ensure AFSC-supported entities comply with monitoring, and AFSC must comply with the reporting requirements detailed in this opinion for all AFSC-supported cruises. Handling procedures are steps taken to return a live animal to the sea or transfer a dead animal to the appropriate facility. Below we describe mitigation measures that apply to all vessels conducting research activities analyzed in this Opinion. Next, we describe mitigation measures that apply in specific situations depending on type of gear, area, or species deterrence are detailed. Finally, we review monitoring and reporting requirements and handling procedures.

2.1.5.2 Mitigation Measures used on all vessels conducting AFSC, AFSC-supported, and IPHC research activities

2.1.5.2.1 Marine Mammal Visual Monitor (MMVM)

Because of limited berthing space and other constraints, having a dedicated protected species observer (PSO) on board may not be possible on all AFSC, IPHC, or AFSC-supported cruises. The designated chief scientist, field party chief, or lead sampler will be the MMVM or may assign another person to fulfill the MMVM role. AFSC will provide training developed in collaboration with the North Pacific Groundfish and Halibut Observer Program, and an MMVM packet to staff assigned these duties. The vessel captain or operator may frequently take on the role of monitoring and avoiding protected species while the MMVM is fulfilling required assignments elsewhere on the vessel. Prior to the cruise, MMVMs receive training in marine mammal and sea turtle species identification and the AFSC Mitigation and Monitoring protocols including active avoidance, the move-on rule, recording, and reporting. AFSC will train the designated MMVMs (Chief Scientist, Field Party Chief, and other key personnel) on monitoring, mitigation, and handling procedures before the cruise commences.

- Briefings between MMVM and any vessel crew who may look out for marine mammals occur prior to the start of all research activity, and again when new personnel join the crew, in order to explain responsibilities, communication procedures, marine mammal monitoring protocol, protected species incidental take (PSIT) reporting, and operational and handling procedures, whether occurring on AFSC, AFSC-supported, or IPHC cruises.

MMVM duties are as follows:

- Serve as a trained marine mammal visual monitor.
- Alert the vessel operator and vessel crew to the presence of any listed species.
- When protected or listed species are present, the MMVM will direct all vessel action necessary to initiate mitigation procedures including, for example, humpback whale approach regulations and the move-on rule.
- The MMVM will use the AFSC Protected Species Interaction Form or another consistent reporting mechanism to document less common marine mammal sightings and all vessel/marine mammal direct interactions.
- The MMVM will immediately report to their Directorate:
  - Any and all direct interactions between a marine mammal and the vessel or gear. Direct interactions include vessel strikes, gear strikes, capture, injury, and mortality.
  - Significant observations of the following: any North Pacific right whale, Cook Inlet Beluga Whale, or any stampeding caused at Steller Sea Lion rookeries by the research operation.
- Other significant observations (defined below) will be reported after the cruise is over.
- The MMVM documentation will include as much information as possible about

observations and direct interactions including time; weather; viewing conditions; sea state; distance from vessel; depths; and numbers, sizes, and sex, of listed species.

MMVM requirements are as follows:

- MMVM will be aboard all research vessels to watch for listed marine mammals and protected species, implement mitigation measures, and record significant observations and direct interactions with listed marine mammals or protected species, as described below. MMVM should record the following significant observations:
    - Marine mammals entering into the gear deployment area or waters within 100 yards of the vessel;
    - Sightings of less common marine mammals including Cook Inlet DPS beluga whale, North Pacific right whale, blue whale, or sperm whale;
    - As many photos as possible of North Pacific right whale (head shots are most helpful in identification);
    - Marine mammals that do not move from a research site or survey station;
    - Marine mammals that display unusual behavior or change behavior;
    - Large groups of listed marine mammals (greater than 10 humpback whales or more than 2-3 of other species);
    - If visible from the vessel, observe Steller Sea Lions at rookeries or haulouts and determine whether any alert, startle, or movement behavior (Table 79) is observed during the time the vessel is operating in the area, including any stampeding caused at Steller Sea Lion rookeries by the research operation.
    - Direct interactions where a marine mammal contacts the vessel, is captured by or contacts the research gear or is injured from the gear, or the animal is otherwise injured or killed due to the research operation.
- MMVM or designee will look and listen for marine mammals at least 15 minutes before approaching or occupying a study site or survey station and immediately report any sightings to the vessel operator so that appropriate avoidance procedures can be invoked.
- MMVM or designee will watch for marine mammals while conducting a transect.
- MMVM will achieve 100% monitoring coverage of gear deployment areas.
- During transit between stations, the MMVM or designee will monitor for listed marine mammals and protected species.
- The MMVM or designee should avoid continuous long durations (>4 hours at a time, more than 12 hours per day) of monitoring during transits, gear deployment, and transects to prevent fatigue.
- MMVM must be trained prior to cruise. Previous marine mammal observation experience is extremely helpful.
- MMVM shall be trained using visual aids (e.g., videos, photos) to help them identify the species in the conditions that they are likely to encounter prior to the cruise.
- Within safe limits, the MMVM should be stationed where they have the best possible viewing. Viewing may not always be best from the ship bridge, and in some cases may be best from higher positions with less visual obstructions (e.g., flying bridge), but safety and vessel configuration will determine alternate viewing platforms.
- MMVMs will identify animals as unknown where appropriate rather than strive to

identify a species if there is significant uncertainty.
- MMVMs should maximize their time with eyes on the water. This may require new means of recording data (e.g., audio recorder) or the presence of a data recorder so that the MMVMs can simply relay information.
- MMVMs will immediately report direct interactions to their Division Directorate, who will then notify the AFSC Environmental Compliance Officer, Alaska Region Protected Resources Specialists, and the Alaska Marine Mammal Stranding Network.

The following equipment shall be available to MMVMs to ensure adequate coverage of the area to be monitored:

- Satellite phone with contact information or email system to communicate direct interactions including injuries and mortalities to survey managers;
- Survey managers shall contact the NOAA Fisheries Stranding Network and document direct takes with the NMFS Protected Species Incidental Take (PSIT) system;
- Daily tide and current tables for the action area;
- Stopwatch or timekeeping device;
- High magnification binoculars;
- Rangefinder;
- GPS and compass;
- PSIT or equivalent electronic forms;
- Electronic or hard copy of the final LOA;
- Electronic or hard copy of the final Biological Opinion with Terms and Conditions; and
- Clipboard and pencils or computer, as available.

2.1.5.2.2 The "Move On" Rule

If a marine mammal or other protected species is at risk from a research activity before setting gear or when occupying the site, then the research activity will stop until the animal moves away and is no longer at risk. If the animal does not move from the research site, then the research activity must be moved to an alternate location or canceled so there is no longer a risk to the animal or other protected species. If a protected species is encountered during a research activity when gear is deployed, then the vessel shall maintain course, slow down, or take other actions to avoid direct contact of the animal with the vessel or gear. The "Move On" Rule has been formally used by AFSC since 2014 and informally prior to that.

2.1.5.3 Mitigation measures designed to minimize impacts to particular species that apply to all vessels

Vessels shall use the Move On rule in all research activities to minimize the risk of interaction with listed marine mammals and other vulnerable protected species.

Vessels engaged in research activities will follow the NMFS Code of Conduct for Marine Mammal Viewing (https://alaskafisheries.noaa.gov/pr/mm-viewing-guide).

- Remain at least 100 yards from marine mammals.

- Time spent observing individual(s) animals should be limited to 30 minutes.
- Whales should not be encircled or trapped between boats, or boats and shore.
- If approached by a whale, put the engine in neutral as sea conditions allow and allow the whale to pass

2.1.5.4 Additional mitigation measures that lower the risk of vessel strike of all listed species

- The MMVM and captain should engage in active avoidance of listed marine mammals using their best professional judgement and take direct action to avoid ship strikes such as slowing down, altering course, stopping, or even reversing course.
- Tow speed during surveys and transit speed between survey stations are kept slow (specific speeds are listed in Table 1) to minimize the risk of vessel strike. AFSC and AFSC-supported research vessel speeds during trawling or deploying sampling gear (other than acoustic equipment) will be less than 5 knots. IPHC vessel speeds will be less than 4 knots when research vessels are actively setting gear, and less than 2 knots when hauling gear.
- When transiting between sampling stations in designated critical habitat for Steller sea lion, North Pacific right whale, or Cook Inlet beluga whale and when conducting acoustic surveys in these critical habitat areas, vessels must slow to an effective speed of 10 knots any time the marine mammals are observed within an estimated distance of 0.5 nautical miles.
- When transiting through passes in the Aleutian Islands and through the Bering Strait, the MMVM and vessel operator will be extra vigilant in maintaining a watch and will assign additional watch standers if possible due to heavy use of these passes by marine mammals, including North Pacific right whale.
- Tow durations will be kept short when possible to minimize interactions with marine mammals.
- Vessels may conduct research operations at night, transit between stations, jog or run patterns to maintain position and sea friendliness, drift, or anchor. For night-time research operations, the MMVM and vessel operator will be extra vigilant in maintaining a watch, assign additional watch standers, listen for blows, and/or delay operations in areas of likely marine mammal occurrence. When deploying gear at night, forward areas of the ship can remained darkened for navigational purposes but visibility amidships and aft must be at least 50 yards around the vessel, usually accomplished with vessel lights. During night time or limited visibility gear deployments, the research area around the ship should be searched for marine mammls before gear deployment.

2.1.5.5 Humpback Approach Regulations

Vessels engaged in research activities shall adhere to the Alaska Humpback Whale Approach Regulations at all times (see 50 CFR §§ 216.18, 223.214, and 224.103(b)). These regulations require that all vessels:

- Not approach within 100 yards of a humpback whale, or cause a vessel or other object to approach within 100 yards of a humpback whale,

- Not intercept or place vessel in the path of oncoming humpback whales causing them to surface within 100 yards of vessel,
- Not disrupt the normal behavior or prior activity of a whale, and
- Operate all vessels at a slow, safe speed when near a humpback whale (safe speed is defined in regulation (see 33 CFR § 83.06)).

2.1.5.6 Right Whale Approach Regulations (50 CFR § 224.103(c) Special prohibitions for endangered marine mammals)

- *Prohibitions.* It is unlawful for any person subject to the jurisdiction of the United States to commit, attempt to commit, to solicit another to commit, or cause to be committed any of the following acts:
  - Approach (including by interception) within 500 yards (460 m) of a right whale by vessel, aircraft, or any other means;
- *Right whale avoidance measures.* The following avoidance measures must be taken if within 500 yards (460 m) of a right whale:
  - If underway, a vessel must steer a course away from the right whale and immediately leave the area at a slow safe speed.

2.1.5.7 Procedures to Minimize the Chance of Disturbing Steller sea lions (SSL) within the no-transit zones around major SSL rookeries and near major SSL haulouts

In order to avoid take, the following process will exclude research activities in places and times where Western DPS Steller sea lion can be especially vulnerable.

After random survey stations have been selected, AFSC, MML, and AKR PRD staff will review details of sites selected that are within 3 nautical miles (nm) of rookeries and haulouts. Staff will plot selected stations along with the explicit length of shore occupied by Steller sea lions at rookeries and haulouts (Lewis *et al* 2018). Staff will review any specific information about the rookeries and haulouts, and whether or not the selected station is in direct line of sight and sound to any part of the length of occupied shoreline (for example, on the other side of an island). If this review shows that disturbance at the rookeries and/or haulouts is unlikely from research activities at the selected survey station, then the station may be included, subject to the move-on rule and other mitigation measures. If this review shows that disturbance is likely:

- Within 3 nm of Steller Sea Lion rookeries on the list in Appendix A:
  - Research activities at that station shall be avoided between April 20 and June 30.
- During other time periods at rookeries and year-round at haulouts, vessels should not transit within 2 nm of Steller Sea Lion rookeries and haulouts on the list in Appendix A.

If Steller sea lion disturbance behavior is observed at terrestrial locations other than haulouts or rookeries listed in Appendix A during research activities, the research vessel will move farther offshore. This is particularly important for haulouts and rookeries in the Aleutian Islands where the western DPS decline is currently the greatest and the animals there may be more easily disturbed than animals in other locations in Alaska where they may have habituated to terrestrial disturbance.

2.1.5.8 Gear-specific mitigation measures

2.1.5.8.1 Research activities using trawl gear

Applying the "Move-On" Rule to trawl surveys

If any marine mammals appear to be at risk of interaction with trawl gear at a survey station, before setting gear the vessel either waits for the marine mammals to "move on" from the survey station, or the vessel "moves on" to another sampling station. Most research vessels engaged in trawling will have their station in view for 15 minutes or 2 nm prior to reaching the station, depending upon the sea state and weather. Many vessels will inspect the tow path before deploying the trawl gear, adding another 15 minutes of observation time and gear preparation prior to deployment. If marine mammals are observed at or near the station, the Chief Scientist and the vessel operator will determine the best strategy to avoid potential takes based on the species encountered, their numbers and behavior, their position and vector relative to the vessel, and other factors. After moving on, if marine mammals are still visible from the vessel and appear to be at risk, the Chief Scientist may decide, in consultation with the vessel operator, to move again or to skip the station. In many cases, the survey design can accommodate sampling at an alternate site. Trawl gear is not deployed if marine mammals have been sighted from the ship in its approach to the station unless those animals do not appear to be in danger of interactions with the trawl, as determined by the judgment of the Chief Scientist or designated MMVM on watch. An example of allowable conditions when a vessel might not necessarily need to move on could be when marine mammals are feeding or residing more than 0.25 nm (500 m) from the vessel and not making directed movements toward the vessel. The efficacy of the "move-on" rule is limited during night time or other periods of limited visibility, although operational lighting from the vessel illuminates the water in the immediate vicinity of the vessel during gear setting and retrieval. In these cases, it is again the judgment of the Chief Scientist as based on experience and in consultation with vessel operator to exercise due diligence and to decide on appropriate course of action to avoid unintentional interactions.

Once the trawl net is in the water, the MMVM, vessel operator, or other designated personnel continue to monitor the waters around the vessel and maintain a lookout for marine mammals as environmental conditions allow (as noted previously, visibility can be limited by fog, rain, or night, but visibility of at least 50 m around the vessel will be required for operations. If marine mammals are sighted before the gear is fully retrieved, the most appropriate response to avoid incidental take is determined by the professional judgment of MMVM and vessel operator. These judgments take into consideration the species, numbers, and behavior of the animals, the status of the trawl net operation (net opening, depth, and distance from the stern), the time it would take to retrieve the net, and safety considerations for changing speed or course. During haul-back operations, there is the potential for entanglement of marine mammals as the net is retrieved, especially when the trawl doors have been retrieved and the net is near the surface and no longer under tension. If a marine mammal is sighted during haul-back, the risk of entanglement may be reduced if the trawling continues and the haul-back is delayed until after the marine mammal has lost interest in the gear or left the area. Other mitigative actions might be to maintain the course, retrieve the gear as soon as possible, slow down, stop, or in extreme situations, change course. The appropriate course of action to minimize the risk of incidental take of protected species is determined by the professional judgment of the MMVM and vessel operator based on all situation variables, even if the choices compromise the value of the data collected at the station.

Additional mitigation measures on surveys using trawl gear

- No offal discard immediately prior to or during the trawling at a station, and
- Minimize trawling at night when possible.

2.1.5.8.2 Research activities using longline gear

The AFSC Longline Survey uses bottom longline gear with two 8 kilometer (km) long sets per day. The IPHC survey uses shorter longlines up to 3 nm (6.1 km) and usually deploys three longlines per day. Longline gear is set at predetermined stations if no listed species are present, and the gear is allowed to soak for a minimum of three hours for the AFSC survey and for a minimum of five hours for the IPHC survey before haul-back begins. Due to the length of the mainline and numbers of hooks involved, it takes up to three to eight hours to complete the haul-back. If whales are present at haul-back, the AFSC sablefish survey vessel should continue retrieving the gear as quickly as possible in order to minimize interactions. If whales are present during IPHC haul-back, the gear may be dropped or left and another line retrieved to give the chance for the whales to leave the area near the first line. Because some species of whales (including sperm whales) have learned the sounds associated with longline operations and sometimes appear as the gear is being retrieved, two primary strategies are used to minimize interactions. The strategies differ because of the length and time to set and retrieve the single AFSC longline and the shorter and greater number of longlines used by the IPHC survey. Both approaches seek to minimize the exposure time of the gear to whale depredation. For AFSC survey longlines, allowing the line to sink back down for a later retrieval is impractical as whales can wait in the area for days and fish caught on the line can still be eaten by the whales or other marine organisms. Furthermore, since the two AFSC longlines are usually laid end-to-end, dropping one set and retrieving the other set would not deter the whales because the spatial separation between sets is small enough that the whales could easily swim the distance between the two sets. In contrast, the IPHC usually deploys three, 3 nm longlines per day, in different areas, so the spatial separation between the deployed longlines means that dropping one where whales are present to retrieve another line will allow the whales time to leave the first line. If whales follow the vessels between survey stations, the survey pattern may be altered to increase the distance between stations as a means to dissuade the animals from this behavior and to avoid continued interactions. In general, the IPHC only infrequently encounters sperm whale depredation while depredation is more common for the AFSC Survey in southeastern Alaska where catch rates may be reduced by over 12% when whales are present. Depredation is infrequent but more common for the IPHC Survey, along the Eastern Bering Sea slope than in southeastern Alaska.

AFSC and IPHC longline protocols specifically prohibit chumming (i.e., releasing additional bait to attract target species to the gear) before or during the longline setting operations. However, longline surveys are conducted on contracted commercial fishing catcher/processor vessels and fish are processed as the longline is retrieved. On the AFSC survey vessel, catch is processed aboard the vessel, and offal is macerated and discharged off the side opposite of gear retrieval. This minimizes the attraction to marine mammals and keeps seabirds away from the gear being retrieved. On IPHC survey vessels, bait and undesirable fish are immediately returned to the sea. Due to the small vessels and amount of catch, it is impossible to retain the catch and discard it at another time. Low documented take rates indicate that the current protocols used by both the AFSC and IPHC surveys to discharge offal, used bait, and discards are conservative processes that reduce the rate of interaction with marine mammals.

2.1.5.8.1 Research activities using gillnet gear

If no marine mammals are present, the gear is set and monitored continuously during the soak. If a marine mammal is sighted during the soak and appears to be at risk of interaction with the gear, then the gear is pulled immediately in order to minimize the time the net is in the water and exposed to nearby marine mammals. Acoustic pingers may be used to reduce the chance of encounters. Small mesh gillnets are used in AFSC surveys, which may further reduce interactions with marine mammals.

2.1.5.8.2 Research activities using plankton nets, oceanographic sampling devices, echosounders and other acoustic equipment, video cameras, SCUBA divers, and remotely operated vessel (ROV) deployments

The AFSC, IPHC, and AFSC-supported entities deploy a wide variety of gear to sample the marine environment during all of their research cruises, including but not limited to plankton nets, oceanographic sampling devices, video cameras, high-frequency active acoustics (outside the hearing range of listed marine mammals), Autonomous Underwater Vehicle (AUVs), ROVs, and a variety of less commonly used small nets. It is not anticipated that these types of gear or equipment would interact with protected species; however, the officer on watch and crew monitor for any unusual circumstances that may arise at a sampling site and use their professional judgment and discretion to avoid any potential risks to protected species during deployment of all research equipment.

2.1.5.9 Mitigation measures pertaining to oil spills

All research vessels will take measures to prevent and mitigate oil spills, including:

- using absorbent booms when transferring fuel;
- training crew on safety, prevention, and emergency response;
- reporting spills when they occur;
- storing adequate oil and fuel clean-up equipment and supplies; and
- following all MARPOL rules as discussed below.

In the unlikely event of an oil spill, AFSC, IPHC, AFSC-supported entities shall comply with international, federal, state, and local requirements to prevent, minimize, and report oil discharges. All vessels are subject to the regulations of MARPOL 73/78, the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (NOAA 2010a). MARPOL includes six annexes that cover discharge of oil, noxious liquid substances, harmful packaged substances, sewage, garbage, and air pollution.[2] Annex V specifically prohibits plastic disposal anywhere at sea and severely restricts discharge of other garbage.

2.1.6 Monitoring and reporting requirements

The following requirements describe how the research activities' effects on listed species will be monitored and reported. In addition, AFSC and IPHC must adhere to all monitoring and reporting requirements as detailed in the LOA issued by NMFS under section 101(a)(5) of the MMPA. The AFSC must include monitoring and reporting for its AFSC-supported operations. Notwithstanding the monitoring and reporting described here, for purposes of our analysis in section 6 of this Opinion, we make certain assumptions about effects that are reasonable likely to occur.

2.1.6.1 Monitoring exposure of marine mammals to acoustic noise

AFSC operates scientific echosounder gear that intersects the audio range of several types of marine mammals and is of sufficient intensity to cause harassment due to acoustic noise. For those vessels operating the Simrad ES60, EK 60, and ME70 sonars, the acoustic harassment zone

[2] IMO (International Maritime Organization). 2010. International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL). Available from: http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx, Accessed January 2018.

is expected to be a distance up to 100 m from the vessels (for depth to 500 m). This equipment is within the hearing range of all listed species included in this opinion. The R/V *Fairweathe*r uses the Reson 7111 on the FISHPAC survey. Frequencies emitted by these systems are only within the hearing range of sperm and Cook Inlet Beluga whales, as well as listed pinnipeds.

Because the acoustic harassment zone is directly under the vessel and in most cases, moving along a track line, typical monitoring and accounting procedures would be difficult to conduct. Instead, estimates of exposure of listed species to acoustic noise were calculated by multiplying animal density in each area and depth stratum by the volume of water ensonified. Direct observations during research activities will be recorded whenever possible and reported at end of season, and actual exposure for this action will be estimated after the surveys, by using the actual line transects travelled multiplied by the same assumed uniform densities. AFSC will provide actual km surveyed and estimated exposures, as well as a detailed description of direct observations to NMFS AKR at the end of each season.

2.1.6.1.1 Calculation of listed humpback whale DPSs

Humpback whale exposure will be calculated as described above. To then calculate Level B harassment of the Mexico and Western North Pacific DPSs, AFSC will use the proportion of humpback whales from those DPS expected to be present in the action area (Table 6 adapted from (Wade et al. 2016)). The calculated exposure of humpback whales is multiplied by the appropriate percentage for each DPS according to the research area in which the survey was conducted. That number will be considered Level B harassment of the Mexico and Western North Pacific DPSs, and will be recorded and reported as such.

Table 6. Probability of encountering humpback whales from each DPS in the North Pacific Ocean (columns) in various feeding areas (rows). NOTE: For the endangered Western North Pacific DPS, these percentages reflect the upper limit of the 95% confidence interval of the probability of occurrence in order to give the benefit of the doubt to the species and to reduce the chance of underestimating potential takes.

Summer Feeding Areas	**AFSC Research Areas**	**IPHC Research Areas**	**North Pacific Distinct Population Segments**	
			Western North Pacific DPS (endangered)	**Mexico DPS (threatened)**
Aleutian Islands, Bering Sea Chukchi & Beaufort Seas	BSAIRA BSAIRA CSBSRA	4A 4B 4C 4D 4E N/A	4.4%	11.3%
Gulf of Alaska (between Yakutat and the Alaska Peninsula)	GOARA	3A 3B	0.5%	10.5%
Southeast Alaska	GOARA	2C	0%	6.1%

2.1.6.1.2 Other species

In addition, AFSC and AFSC-supported entities will record any observations of sperm whales while using the Reson 7111. Cook Inlet beluga whales and ringed and bearded seals could also be affected by these frequencies, but NMFS expects that interactions with these species will be limited because of infrequent overlap between the survey's sampling and the species' distributions. If research vessels observe these species while using the Reson 7111, those observations must also be recorded.

2.1.6.2 Monitoring exposure of marine mammals to entanglement

The MMVM will use the AFSC Protected Species Interaction Form to report significant observations of marine mammals (as defined earlier in this section) and any direct interactions, including entanglements (as defined earlier in this section).

2.1.6.3 Monitoring exposure of Steller sea lions to terrestrial disturbance

The MMVM will use the AFSC Protected Species Interaction Form to report any observations of Steller sea lions exhibiting disturbance behavior on land, including hauled-out individuals flushed into the water or whole groups stampeding into the water.

2.1.6.4 Annual Reporting Requirements

An annual report will be provided to AKR PRD (via email to Kristin.Mabry@noaa.gov) before April 1 detailing the previous year's activities covered under this opinion (and LOA), which includes:

- Species composition, occurrence, and distribution of significant observations of marine mammals (as defined earlier in this section), including date, water depth, numbers, age/size/gender categories (if determinable), and group sizes;
- An estimate of the number (by species) of: listed pinnipeds and cetaceans that have been exposed to acoustic noise at received levels greater than or equal to 160 dB re 1 µPa (rms) with a discussion of any specific behaviors those individuals exhibited;
- Detailed accounts of any direct interactions;
- PSIT forms;
- Photos captured of any marine mammals.

In addition, an annual meeting with MMVMs, survey leads or coordinators, and PRD staff will be scheduled when the report is provided to review the project's interactions with listed species and the effectiveness of mitigation measures, any anticipated changes to surveys, and necessary improvements to the reporting process. Monitoring reports, annual meetings, and adaptive management will help to judge the efficacy, implementation, and compliance of this opinion's mitigation measures, best management practices, and standard operating procedures.

2.1.7 Handling Procedures for Incidentally Captured Marine Mammals

If a large whale is alive and entangled in fishing gear, the vessel should immediately call the NMFS Alaska Marine Mammal Strainding Network reporting hotline at (877) 925-7773, 24 hour availability). Often, a real-time communication can occur that gives practical advice for the set of circumstances of the entanglement. The online reporting form at https://alaskafisheries.noaa.gov/strandingnotice should also be filled out and submitted to document the interaction.

Incidentally captured marine mammals are released from the gear without removing them from the water if possible. If they are taken from the water they are returned as soon as possible and all gear, or as much as practical, is removed from the animal. Data collection is conducted on incidentally captured animals such that their release is not delayed. If the safety of the crew and captured animal will not be compromised, the scientific party will attempt to collect biological information from captured marine mammals before they are released, including species identification, sex identification (if genital region is visible), estimated length, and photographs. Photos of captured cetaceans should include an image of the left and right side of the dorsal fin; any distinguishing features, especially tags, brands, fluke markings, etc., to help determine stock ID; and a picture of the nature of gear entanglement. Information should also describe whether the animal was seen prior to the entanglement, a description of its behavior, and any mitigation measures used and/or discretionary decisions made by the Chief Scientist (Lead Sampler), including a rationale for those decisions. This information will be recorded in the research cruise logbook and conveyed to the NMFS PSIT notification system within 24 hours of capture or as soon as ship to shore communication allows.

2.2 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For this reason, the action area is typically larger than the project area and extends out to a point where no measurable effects from the proposed action occur.

Survey stations are spread throughout the waters off Alaska including the exclusive economic zone (EEZ) and coastal or "state" waters, and vessels must transit to and between survey stations. Because the exact survey stations change from year to year and the exact vessel routes to, from, and between stations can be unpredictable due to weather and other safety factors, the three entire research areas, GOARA, BSAIRA, and CSBSRA, approximately three million square miles, are considered to be the action area for this analysis. Figure 1 displays these three research areas and the spatial extent of the surveys that are widely distributed geographically. Note that only a subset of the possible survey locations is surveyed in any single year. This consultation is limited to actions occurring in waters off Alaska.

The IPHC survey is widespread across the Bering Sea, Aleutian Islands, Gulf of Alaska (including inland waters of Southeast Alaska), and along the U.S. west coast. Effects to listed species from the portion of the IPHC survey that occurs in waters off Alaska are analyzed in this opinion. The NMFS West Coast Region's biological opinion covered effects to ESA-listed species from the 2018 halibut fishery and IPHC's research off of Washington, Oregon, and California (NOAA 2018).

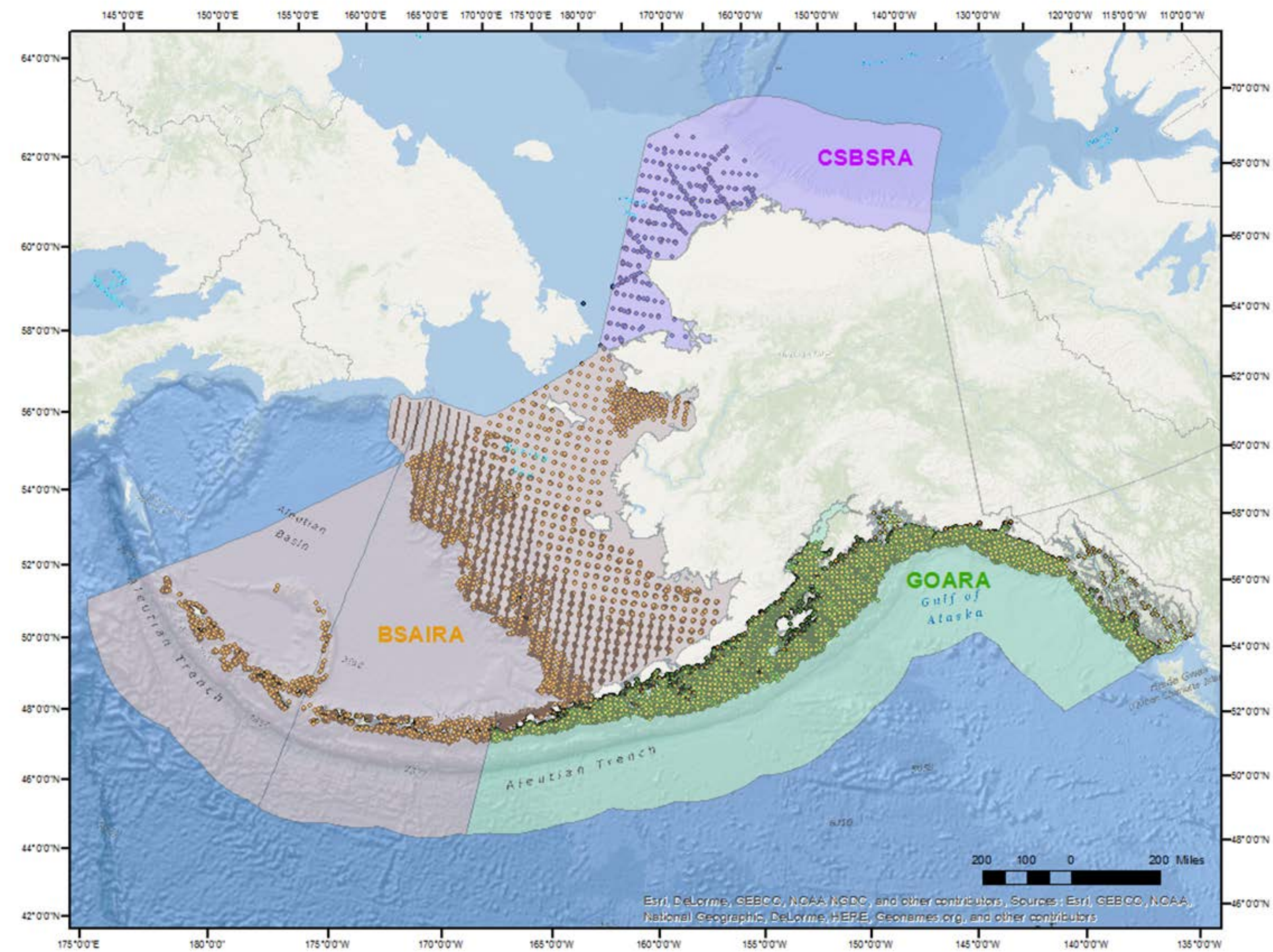

Figure 1. The action area for this opinion includes the GOARA, BSAIRA, and the CSBSRA. These three research areas are shown here. In addition, the spatial extent of possible survey locations is depicted by points and lines. Note that only a subset is surveyed in any single year.

3. Approach to the Assessment

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. The jeopardy analysis considers both survival and recovery of the species. The adverse modification analysis considers the impacts to the conservation value of the designated critical habitat.

To jeopardize the continued existence of a listed species means to engage in an action that "would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). As NMFS explained when it promulgated this definition, NMFS considers the likely impacts to a species' survival as well as likely impacts to its recovery. Further, it is possible that in certain, exceptional circumstances, injury to recovery alone may result in a jeopardy biological opinion (51 FR 19926, 19934; June 3, 1986).

Under NMFS' regulations, the destruction or adverse modification of critical habitat "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (50 CFR 402.02).

Older designations of critical habitat for listed species use the terms "primary constituent element" (PCE) or "essential features". Critical habitat regulations (81 FR 7414; February 11, 2016) replace these terms with the term "physical or biological features" or "PBFs." The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

We use the following approach to determine whether the proposed action described in Section 2 is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify those aspects (or stressors) of the proposed action that are likely to have direct or indirect effects on listed species or critical habitat. As part of this step, we identify the action area – the spatial and temporal extent of these direct and indirect effects.
- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action. This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. We determine the rangewide status of critical habitat by examining the condition of its PBFs - which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 4 of this opinion.

- Describe the environmental baseline including: past and present impacts of Federal, state, or private actions and other human activities *in the action area*; anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation; and the impacts of state or private actions that are contemporaneous with the consultation in process. The environmental baseline is discussed in Section 5 of this opinion.

- Analyze the effects of the proposed actions. Identify the listed species that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our *exposure analyses*). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to stressors and the populations or subpopulations those individuals represent. NMFS also evaluates the proposed action's effects on critical habitat features. The effects of the action are described in Section 6 of this opinion with the exposure analysis described in Section 6.2 of this opinion.

- Once we identify which listed species are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those listed species are likely to respond given their exposure (these represent our *response analyses*). Response analysis is considered in Section 6.3 of this opinion.

- Describe any cumulative effects. Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 7 of this opinion.

- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat. In this step, NMFS adds the effects of the action (Section 6) to the environmental baseline (Section5) and the cumulative effects (Section 7) to assess whether the action could reasonably be expected to: 1) appreciably reduce the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution; or 2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species and critical habitat (Section 4). Integration and synthesis with risk analyses occurs in Section 8 of this opinion.

- Reach jeopardy and adverse modification conclusions. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 9. These conclusions flow from the logic and rationale presented in the Integration and Synthesis Section 8.

- If necessary, define a reasonable and prudent alternative to the proposed action. If, in completing the last step in the analysis, NMFS determines that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, NMFS must identify a reasonable and prudent alternative (RPA) to the action.

4. RANGEWIDE STATUS OF THE SPECIES AND CRITICAL HABITAT

4.1 Species and Critical Habitat Not Likely to Be Adversely Affected

As described in the Approach to the Assessment section of this opinion, NMFS uses two criteria to identify those endangered or threatened species or critical habitat that are likely to be adversely affected. The first criterion is exposure or some reasonable expectation of a co-occurrence between one or more potential stressors associated with AFSC's or IPHC's research activities and a listed species or designated critical habitat. The second criterion is the probability of a response given exposure. For endangered or threatened species, we consider the susceptibility of the species that may be exposed. For example, species that are exposed to sound fields produced by hydroacoustic research activities, but are not likely to exhibit physical, physiological, or behavioral responses given that exposure (at the combination of sound pressure levels and distances associated with an exposure), are not likely to be adversely affected by the research activity.

We applied these criteria to the listed species known to occur in marine waters off Alaska and determined that the species listed in Table 7 below are not likely to be adversely affected by the proposed action. A brief description of each species and its occurrence in Alaska is provided in the sections below, followed by a rationale for why the action is not likely to adversely affect that species. For all of the species listed in Table 7, either critical habitat has not been designated, or the designated critical habitat is outside the action area; therefore, critical habitat for these species is not discussed further in this opinion.

Table 7. ESA-listed species that may occur in Alaskan waters, but that the action is not likely to adversely affect.

Species	Status	Listing	Critical Habitat	Distribution by Research Area		
				GOARA	BSAIRA	CSBSRA
Gray whale (*Eschrichtius robustus)* Western North Pacific DPS	Endangered	35 FR 18319 December 2, 1970	Not designated	X	X	
Green turtle *(Chelonia mydas)* Central North Pacific DPS and East Pacific DPS	Threatened	81 FR 20058 April 6, 2016	Not designated	X		
Loggerhead turtle (*Caretta caretta)* North Pacific Ocean DPS	Endangered	76 FR 58868 September 22, 2011	Not designated	X		
Olive ridley turtle (*Lepidochelys olivacea)*	Threatened	43 FR 32800 July 28, 1978	Not designated	X		
Leatherback turtle *(Dermochelys coriacea)*	Endangered	35 FR 8491 June 2, 1970	77 FR 4170 January 26, 2012	X		
Steelhead trout *(Oncorhynchus mykiss)* Lower Columbia River DPS	Threatened	71 FR 834 January 5, 2006	70 FR 52630 September 2, 2005	X		
Middle Columbia River DPS	Threatened	71 FR 834 January 5, 2006	70 FR 52630 September 2, 2005	X		
Snake River Basin DPS	Threatened	71 FR 834 January 5, 2006	70 FR 52630 September 2, 2005	X		
Upper Columbia River DPS	Threatened	71 FR 834 January 5, 2006	70 FR 52630 September 2, 2005	X		
Upper Willamette River DPS	Threatened	71 FR 834 January 5, 2006	70 FR 52630 September 2, 2005	X		
Puget Sound DPS	Threatened	72 FR 26722 May 11, 2007	81 FR 9252 February 24, 2016	X		

4.1.1 Gray whale (*Eschrichtius robustus*)

4.1.1.1 Description

Gray whales occur in two genetically distinct populations in the North Pacific Ocean (Cooke et al. 2013; Lang et al. 2011). These are formally recognized as the western North Pacific population that was listed as endangered in 1970 (35 FR 18319; December 2, 1970) under the Endangered Species Act and shows no apparent signs of recovery, and the eastern North Pacific population that has recovered from exploitation and was removed from listing under the ESA in 1994 (Carretta et al. 2013; Swartz et al. 2006). The eastern North Pacific population is not included in this biological opinion (59 FR 31094; June 16, 1994). Although the western North Pacific stock remains listed as endangered under the ESA, there is no designated critical habitat for this species.

The western North Pacific gray whale population was once thought to be extinct after being decimated by whaling prior to the 1970s, but now small numbers are known to exist (Weller et al. 2002). The most recent estimate of this population is 140 individuals (Carretta et al. 2015), and it is believed to be increasing at a rate of 3.3% per year.

Western North Pacific gray whales migrate annually along Asia during autumn, although migration routes are poorly known. Migration from summer foraging areas off the northeastern coasts of Sakhalin Island and south-eastern Kamchatka along the Japanese coasts to the South China Sea is suspected (IWC 2003; IWC 2004; Omura 1988; Tsidulko et al. 2005; Weller et al. 2008; Weller et al. 2012).

Eastern and western North Pacific gray whales were once considered geographically separated along either side of the ocean basin, but recent photo-identification, genetic, and satellite tracking data undermine this. For example, a recent study tracked seven western North Pacific gray whales fitted with satellite tags off Sakhalin Island, Russia, and found that three of the tagged whales migrated to regions occupied by eastern North Pacific gray whales (Mate et al. 2015). Comparisons of eastern and western North Pacific gray whale catalogs have so far identified 23 western North Pacific gray whales occurring on the eastern side of the basin during winter and spring (Weller et al. 2013), and Burdin et al. (2011) found an additional individual. During one field season off Vancouver Island, western North Pacific gray whales were found to constitute 8.1 percent of photo-identifications (Weller et al. 2012). In addition, two genetic matches of western North Pacific gray whales off Santa Barbara, California, have been made (Lang et al. 2011). Individuals have also been observed migrating as far as central Baja Mexico (Weller et al. 2012).

Gray whales are in the low frequency cetacean functional hearing group (Southall et al. 2007).

4.1.1.2 Distribution

Western North Pacific gray whales exhibit extensive plasticity in their occurrence, shifting use areas within and between years, as well as over longer time frames, such as in response to oceanic climate cycles (e.g., El Nino-Southern Oscillation, Pacific Decadal Oscillation, and Arctic Oscillation) (Gardner and Chavez-Rosales 2000; Meier et al. 2007; Tyurneva et al. 2009; Vladimirov et al. 2006a; Vladimirov et al. 2006b; Vladimirov et al. 2005; Vladimirov et al. 2008; Vladimirov et al. 2009; Vladimirov et al. 2010; Weller et al. 2012; Yablokov and Bogoslovskaya 1984; Yakovlev and Tyurneva 2005). Species distribution extends south along Japan, the Koreas, and China from the Kamchatka Peninsula in Russia (IWC 2003; Kato and Kasuya. 2002; Omura 1988; Reeves et al. 2008; Weller et al. 2003). Other possible range states include Vietnam, the Philippines, and Taiwan, although only historical whaling records support occurrence in these areas (Henderson 1990; Ilyashenko 2009). Range has likely contracted from the Koreas and other southern portions of the range as compared to pre-whaling periods. Prey availability and, to a lesser extent, sea ice extent, are probably strong influences on the habitats used by western North Pacific gray whales (Clarke and Moore 2002; Moore 2000b).

4.1.1.3 Distribution in Alaska

Most gray whales follow the coast during migration and stay within 1.2 miles (2 km) of the shoreline, except when crossing major bays, straits, and inlets from southeastern Alaska to the eastern Bering Sea (Braham 1984b). However, gray whales are known to move farther offshore between the entrance to Prince William Sound and Kodiak Island and between Kodiak Island and the southern part of the Alaska Peninsula (Consiglieri et al. 1982). Gray whales use the nearshore areas of the Alaska Peninsula during the spring and fall migrations and are often found within the bays and lagoons, primarily north of the peninsula, during the summer (Navy 2006). During the April 2009 survey of the action area, one group of two gray whales was sighted while on-effort within the action area (Rone et al. 2009). There was one off-effort sighting (25 individuals) southeast of Kodiak Island during a survey of the action area in June and July 2013 (Rone et al. 2014).

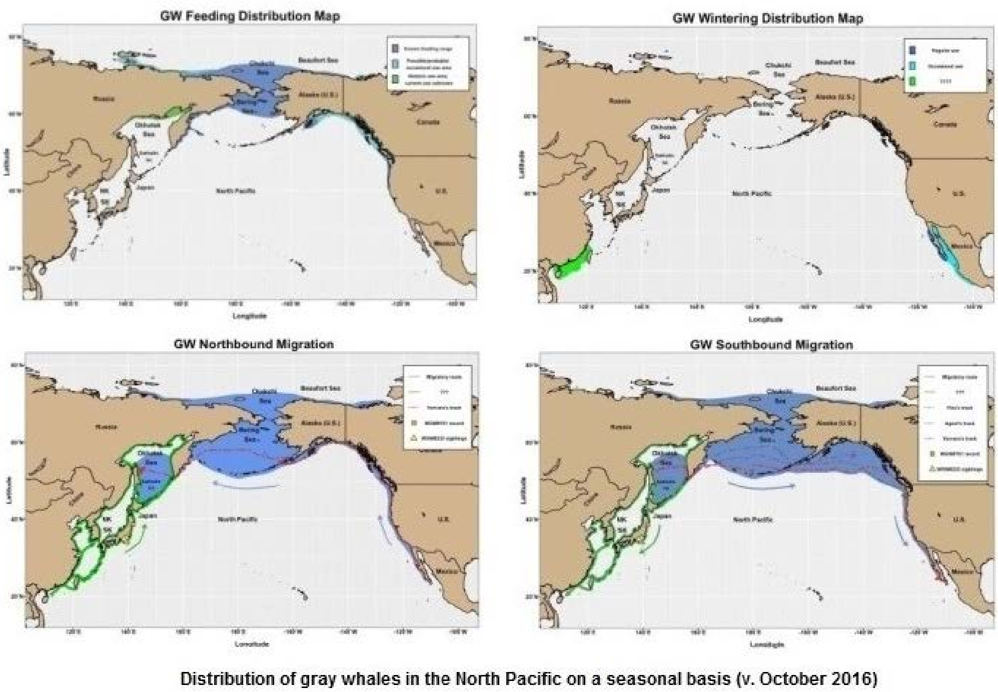

Figure 2. Potential distribution of western North Pacific gray whales. (Source: IUCN, http://www.iucn-csg.org/index.php/western-gray-whale/, Accessed Sept. 19, 2017.)

Gray whale calls were detected during a single hour on a single day, 29 September 2012, at the High-frequency Acoustic Recording Package (HARP) deployed in the slope region of north-central Gulf of Alaska (Baumann-Pickering et al. 2012a). Since gray whales tend to stay close to shore during their migration, the HARP deployment locations are likely too far offshore to capture more gray whale signals (Baumann-Pickering et al. 2012b).

Previous sighting data suggested that the remaining population of gray whales in the western Pacific had a limited range extending between the Okhotsk Sea off the coast of Sakhalin Island (Russia) and the South China Sea (Weller et al. 2002). However, recent long-term studies of radio-tracked whales indicate that the coastal waters of eastern Russia, the Korean Peninsula, and Japan are part of the migratory route (Weller et al. 2012). There is also photographic evidence of a match between a whale found off Sakhalin Island and then off the Pacific coast of Japan, which is more than 932 mi. (1,500 km) south of the Sakhalin feeding area (Weller et al. 2008). Mate et al. (2010) and Mate et al. (2015) documented movement of a western Pacific gray whale from Sakhalin Island to the nearshore waters off Washington State. This whale tracked via long-term satellite tag traveled directly across the southern Gulf of Alaska via a direct path from the Aleutian Islands to Washington State. Further, photo-catalog comparisons of eastern and western North Pacific gray whale populations suggest that there is more exchange between the western and eastern populations than previously thought, since “Sakhalin” whales were sighted off Santa Barbara, California; British Columbia, Canada; and Baja California, Mexico (Weller et al. 2013). Due to the already low abundance of western North Pacific gray whales off Alaska, their occurrence in the action area during the summer time period is considered rare.

Western North Pacific gray whales have not been detected in the Chukchi or Beaufort seas, and their typical migratory route from the Sea of Okhotsk and North America is through the Gulf of Alaska.[3]

4.1.1.4 Stressors and Threats

The population of western North Pacific gray whales was drastically reduced due to commercial hunting off Korea and Japan between the 1890s and 1960s (Carretta et al. 2017). Current threats include incidental catches in coastal net fisheries along the western North Pacific coastline, entanglements, industrialization and shipping congestion through migratory corridors leading to behavioral disruption, increased noise, potential ship strikes, exposure to pollutants, and general degradation of habitat. In addition, oil and gas development in summer foraging habitat off Sakhalin Island increases the exposure to noise, shipping traffic, seismic surveys, and risks associated with oil spills (Carretta et al. 2017). Ocean acidification may also affect the abundance of shell-forming organisms that are important to gray whale diets (Carretta et al. 2017).

Given that few western North Pacific gray whales occur in U.S. waters, it is possible but unlikely that western North Pacific gray whales could be killed or injured by ship strikes or entanglements in fishing gear within U.S. waters (Carretta et al. 2017).

4.1.1.5 Determination

We conclude that because of the extremely low numbers of the western North Pacific gray whale stock in the North Pacific Ocean and their rare occurrence in the Gulf of Alaska and Bering Sea and Aleutian Islands, exposure to stressors such as vessel strike, fisheries gear entanglement, or noise effects as a result of the AFSC or IPHC research activities in Alaska would be extremely unlikely and any effects would therefore be discountable. We concur with AFSC and PR1's determination that the western North Pacific stock of gray whales is not likely to be adversely affected by the proposed action. As a result, this species will not be considered further in this opinion.

4.1.2 Sea turtles

4.1.2.1 Description and Occurrence in Alaska

Four species of sea turtles have been detected in Alaska: green (*Chelonia mydas*), loggerhead (*Caretta caretta*), olive ridley *(Lepidochelys olivacea)*, and leatherback turtles *(Dermochelys coriacea)* (Hodge and Wing 2000) (Table 7). Hodge and Wing (2000) noted that sea turtles have occurred during most of the months of the year in Alaska, and that 75% of all occurrences during July through October. There does not appear to be a connection between sea turtle occurrences in

[3]Dr. David Weller, NOAA Fisheries Southwest Fisheries Science Center, personal communication, September 19, 2017.

Alaska and warm water years (Hodge and Wing 2000). Approximately 20 green turtles, 2 loggerhead turtles, 4 olive ridley turtles, 19 leatherback turtles, and 3 live, unidentified sea turtles have been recorded in Alaska since the 1960s (Hodge and Wing 2000; Ream 2015; Woodford 2011). A database of turtle occurrences in Alaska was maintained by Dr. Bruce Wing at NOAA Fisheries, Auke Bay Laboratory, until 2013, but currently, there is no system to track turtle sightings or strandings in Alaska. Given Alaska's nearly 11,000 miles of coastline and 54,000 miles of shoreline, and its low human population density, it is likely that majority of sea turtle occurrences in Alaska remain undetected (Hodge and Wing 2000).

The hard shell turtles (green, loggerhead, and olive ridley) belong to the family Cheloniidae. Turtles of this family are wide-ranging throughout temperate and tropical seas, but nesting and egg-laying only occur on tropical or warm tropical beaches (Pough et al. 2001). Hard shell sea turtles rarely stray into cold waters, preferring water temperatures around 18˚C and experiencing cold-stress at temperatures below 10˚C (Eckert 1993; Mrosovsky 1980). The low frequency of occurrence of hard shell turtles in Alaska indicates that they are straying beyond their range of tolerance (Hodge and Wing 2000). Most of these sightings involved individuals that were either cold-stressed, likely to become cold-stressed, or already deceased (Hodge and Wing 2000; McAlpine et al. 2002). Thus, the Gulf of Alaska is considered to be outside the normal range for sea turtle species of the family Cheloniidae. Hard shell sea turtles may end up in Alaska after they stray too far north, either intentionally, or accidentally with ocean currents, and become hypothermic as the water cools and are therefore incapable of escaping to warmer waters (Woodford 2011).

Leatherback turtles, in contrast, are cold-tolerant, endothermic turtles that can maintain body temperatures above ambient water temperature and retain heat (Hodge and Wing 2000). Leatherback turtles are also wide-ranging, and tend to forage in temperate waters and nest on tropical or subtropical beaches; however, non-breeders are seen relatively often at high latitudes (MacDonald 2010). McAlpine et al. (2004) suggest that leatherback occurrences off British Columbia are most frequent from July to September and that the species is an uncommon seasonal resident of those waters. It is likely that the same can be said for leatherbacks in Alaskan waters. The occurrence of leatherback turtles in Alaska suggests that they are ranging into marginal habitat (Hodge and Wing 2000).

The green turtle was first listed under the ESA on July 28, 1978 (43 FR 32800). A status review was completed in 2015 that determined 11 DPSs of green turtle distributed globally (Seminoff and coauthors 2015). Two DPS occur in regions of the Pacific under the jurisdiction of the United States: the Central North Pacific DPS and the East Pacific DPS. In 2016, the listing status of each of the 11 DPSs was established and these two DPSs were listed as threatened under the ESA (81 FR 20058; April 6, 2016). A recovery plan for the U.S. Pacific populations was published in 1998 (NMFS and USFWS 1998a). Critical habitat has not been designated for the U.S. Pacific DPSs. Nester abundance for the Central North Pacific DPS is estimated at 3,846 females, and nesting data indicate increasing trends (81 FR p. 200845). Nester abundance for the

East Pacific DPS is estimated at 20,112 females, and nesting data indicate increasing trends (81 FR p. 20085).

The loggerhead turtle was first listed as threatened under the ESA on July 28, 1978 (43 FR 32800). In 2011, 9 DPS of loggerhead turtles were established globally, with two DPS occurring in the United States, and one, the North Pacific Ocean DPS, that may occur rarely in Alaska. The North Pacific Ocean DPS of loggerhead turtle is listed as endangered under the ESA (76 FR 58868; September 22, 2011). A recovery plan for the U.S. Pacific populations of loggerhead turtle was published in 2008 (NMFS and USFWS 2008). Critical habitat has not been designated for this species. The North Pacific Ocean DPS abundance was measured at 7,000-8,000 nests. While recent records indicate an increase in nest abundance, the trend since the mid-1950s has been a substantial decline (76 FR 58868, 58883).

All populations of olive ridley turtle were listed as threatened under the ESA on July 28, 1978 (43 FR 32800), except those that nest along the Pacific coast of Mexico, which were listed as endangered. The olive ridley turtle is considered the most abundant sea turtle in the world, but distinct population segments have not been established for this species. The global population is estimated at around 800,000 nesting females annually, and the global population trend appears to be declining.[4] A recovery plan for U.S. Pacific populations of olive ridley turtles was published in 1998 (NMFS and USFWS 1998c). Critical habitat has not been designated for this species.

The leatherback turtle was listed as endangered under the ESA throughout its global range on June 2, 1970 (35 FR 8491). A recovery plan for U.S. Pacific populations was published in 1998 (NMFS and USFWS 1998b). Critical habitat was designated on land by the USFWS in 1978 (43 FR 43688; September 26, 1978) and by NMFS for marine waters in 1979 (44 FR 17710; March 23, 1979). In 2012, NMFS revised critical habitat for leatherbacks to include additional areas within the Pacific Ocean (77 FR 4170; January 26, 2012). Unlike populations of Atlantic leatherbacks, Pacific leatherback populations have plummeted in recent decades: Western Pacific leatherbacks have declined more than 80 percent and Eastern Pacific leatherbacks have declined by more than 97 percent. Extensive egg harvest and bycatch in fishing gear are the primary causes of these declines.[4]

4.1.2.2 Stressors and Threats

Stressors and threats to sea turtles are similar for all species.[5] Details on specific stressors to individual species are provided in the recovery plans and status reviews for each species.[6] Major global threats include, but are not limited to fisheries interactions such as bycatch, entanglement or entrapment in fishing gear, and vessel strikes; vessel strikes by commercial and recreational

[4] See http://www.nmfs.noaa.gov/pr/species/turtles/index.html for more information. Accessed September 18, 2017.
5 See http://www.nmfs.noaa.gov/pr/species/turtles/threats.html for more information. Accessed September 17, 2017.
6 Available on the NMFS Office of Protected Resources website at http://www.nmfs.noaa.gov/pr/species/turtles/, Accessed September 17, 2017.

vessels; habitat destruction, alteration, or degradation through coastal development, beach armoring, beachfront lighting, recreation, and invasive species; environmental contamination such as pollution from ocean dumping, oil spills, terrestrial run-off, and marine debris; increased ocean noise; legal harvest and illegal poaching of eggs, subadults, and adults; climate change effects such as increasing temperatures that may skew sex ratios of hatchlings and cause higher levels of embryonic mortality, increases in storm frequency and severity, increased erosion may lead to nest failure, shifts in ocean productivity that could affect foraging behavior, growth, survival, and reproductive capacity, and changing ocean currents that may transport turtles away from optimal habitat; disease; and predation by domestic dogs and feral pigs on nesting beaches.

4.1.2.3 Determination

Because sea turtles occur in the Gulf of Alaska only rarely (less than one detected occurrence per year since 1960), we do not expect individual sea turtles to co-occur with AFSC or IPHC research activities in Alaska. Therefore, it is extremely unlikely that sea turtles would be exposed to stressors caused by these research programs in Alaska, and associated effects are discountable. We concur with AFSC and PR1's determination that these species are not likely to be adversely affected by the proposed action. As a result, these species will not be considered further in this opinion.

4.1.3 Steelhead Distinct Population Segments

The Puget Sound (PS) steelhead DPS was first considered for listing on August 9, 1996, and at the time we determined that the PS steelhead DPS did not warrant listing (61 FR 41541). In response to a petition received on September 13, 2004 (70 FR 17223; April 5, 2005), NMFS updated the species' status review. On May 11, 2007, NMFS listed PS steelhead—both natural and some artificially-propagated fish—as a threatened species (72 FR 26722). NMFS concluded that the PS steelhead DPS was likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The geographic boundaries of the Puget Sound steelhead DPS include winter- and summer-run steelhead populations in the river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive). Six artificial propagation programs were listed as part of the DPS (79 FR 20802; April 14, 2014).

The Lower Columbia River (LCR) steelhead DPS was first listed as a threatened species on March 19, 1998 (63 FR 13347). When we re-examined the status of this species in 2006 and 2011, we determined that it still warranted listing as threatened (71 FR 834; January 5, 2006 (2006 final rule), 76 FR 50448; August 15, 2011 (2011 status review)). The listing included all naturally spawned populations of steelhead in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive) and the Willamette and Hood Rivers, Oregon (inclusive). Steelhead in the upper Willamette River basin above Willamette Falls and steelhead from the Little and Big White Salmon rivers in Washington are excluded.

This DPS includes steelhead from seven artificial propagation programs (79 FR 20802; April 14, 2014).

The Upper Willamette River steelhead DPS was first listed as a threatened species on March 25, 1999 (64 FR 14517). When we re-examined the status of this species in 2006 and 2011, we determined that it still warranted listing as threatened (71 FR 834; January 5, 2006 (2006 final rule), 76 FR 50448; August 15, 2011 (2011 status review)). The listing included all naturally spawned populations of winter-run steelhead in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River, inclusive. No artificially propagated steelhead stocks are considered part of the listed species. The hatchery summer-run steelhead in the Willamette Basin are an out-of-basin stock and not considered part of the DPS.

The Middle Columbia River (MCR) steelhead DPS was first listed as a threatened species on March 25, 1999 (64 FR 14517). That status was reaffirmed on January 5, 2006 (71 FR 834); the listing includes all naturally spawned steelhead populations beginning upstream from the Wind River in Washington and the Hood River in Oregon and proceeding to the Yakima River, Washington. It does not include fish from the Snake River basin. Steelhead from seven artificial propagation programs are included in the MCR steelhead DPS (79 FR 20802; April 14, 2014). A recovery plan is available for this species (NMFS 2009a).

The Upper Columbia River (UCR) steelhead DPS was first listed as an endangered species on August 18, 1997 (62 FR 43937); the listing includes all naturally spawning populations of steelhead in the Columbia River and its tributaries upstream of the Yakima River. When NMFS re-examined the status of the UCR steelhead, explicitly taking into account the effect of abundant hatchery steelhead on the immediacy of the risk, we determined that the DPS was likely to become endangered in the foreseeable future (threatened), rather than presently endangered (71 FR 834; January 5, 2006). That listing was set aside on June 13, 2007 (Trout Unlimited et al. v. Lohn; Case Number CV06-0483-JCC), and the status of the species reverted to endangered as a result of the court's order. The district court's order was appealed to the Ninth Circuit and the status reverted once again to Threatened. On August 15, 2011, NMFS announced the results of an ESA 5-year review UCR steelhead (76 FR 50448). After reviewing new information on the viability of this species, ESA section 4 listing factors, and efforts being made to protect the species, NMFS concluded that this species should retain its threatened listing classification. Another review was completed in 2015 (NMFS 2015f) and, given the same considerations, the 2015 status review team found that while there had been some improvement in a number of areas, the risk categories for this species remained unchanged from the previous review. Steelhead from six artificial propagation programs are included in the UCR steelhead DPS. A recovery plan is available for this species (Upper Columbia Salmon Recovery Board 2007).

The Snake River (SR) steelhead DPS was first listed as a threatened species on August 18, 1997 (62 FR 43937). NMFS reaffirmed the listing of this DPS as threatened on January 5, 2006 (71

FR 834); the listing includes all naturally spawning populations of steelhead in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho. The SR steelhead DPS includes hatchery fish produced by six artificial propagation programs.

4.1.3.1 Determination

Auke Creek weir is the only research activity in the AFSC research program that has reported capturing steelhead. The weir is located at the mouth of Auke Creek, about ten miles northwest of Juneau, AK. During the five-year period (2009-2013) used as the basis for analysis of effects for the AFSC Fisheries Research Draft Programmatic Environmental Assessment (URS 2016), only 75 steelhead were caught in the weir. The AFSC has never reported catching ESA-listed steelhead or any other ESA-listed salmonid species at the Auke Creek weir. Therefore, it is extremely unlikely that the various surveys and studies in AFSC's research program would capture ESA-listed steelhead, and any associated effects are discountable. AFSC's research program is not likely to adversely affect the ESA-listed steelhead DPSs considered in this biological opinion. We therefore concur with AFSC and PR1's determination that these species are not likely to be adversely affected by the proposed action, and these species will not be considered further in this opinion.

4.2 Status of Listed Species – Marine Mammals

This opinion examines the status of each species that is likely to be adversely affected by the proposed action (Table 8). The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, and discusses the current function of the essential PBFs that help to form the conservation value for a listed species.

This section consists of narratives for each of the endangered and threatened species that occur in the action area and that may be adversely affected by the proposed action. In each narrative, we present a summary of information on the population structure and distribution of each species to provide a foundation for the exposure analyses that appear later in this opinion. Then we summarize information on the threats to the species and the species' status given those threats to provide points of reference for the jeopardy determinations we make later in this opinion. That is, we rely on a species' status and trend to determine whether or not an action's direct or indirect effects are likely to increase the species' probability of becoming extinct or reduce both the survival and recovery of the species.

Table 8. The following marine mammal species and designated critical habitats are considered in this Biological Opinion:

Species	Status	Listing	Critical Habitat	Distribution by Research Area		
				GOARA	BSAIRA	CSBSRA
Blue Whale *(Balaenoptera musculus)*	Endangered	35 FR 18319 December 2, 1970	Not designated	X	X	
Sei Whale *(Balaenoptera borealis)*	Endangered	35 FR 18319 December 2, 1970	Not designated	X	X	
Beluga Whale *(Delphinapterus leucas)* Cook Inlet DPS	Endangered	73 FR 62919 October 22, 2008	76 FR 20180 April 11, 2011	X		
Fin Whale *(Balaenoptera physalus)*	Endangered	35 FR 18319 December 2, 1970	Not designated	X	X	X
Humpback Whale *(Megaptera novaeangliae)* Western North Pacific DPS	Endangered	81 FR 62260 September 8, 2016	Not designated	X	X	X
Humpback Whale *(Megaptera novaeangliae)* Mexico DPS	Threatened	81 FR 62260 September 8, 2016	Not designated	X		
Sperm Whale *(Physeter macrocephalus)*	Endangered	35 FR 18319 December 2, 1970	Not designated	X	X	
Bowhead Whale *(Balaena mysticetus)*	Endangered	35 FR 18319 December 2, 1970	Not designated		X	X
North Pacific Right Whale *(Eubalaena japonica)*	Endangered	73 FR 12024 March 6, 2008	73 FR 19000 April 8, 2008	X	X	
Bearded Seal (*Erignathus barbatus*) Beringia DPS, Okhotsk DPS	Threatened	77 FR 76740 December 28, 2012	Not designated		X	X
Ringed Seal (*Phoca(=Pusa) hispida hispida*)	Threatened	77 FR 76706 December 28, 2012	Not designated		X	X
Steller Sea Lion (*Eumetopias jubatus*) Western DPS	Endangered	62 FR 24345 May 5, 1997	58 FR 45269 August 27, 1993	X	X	

4.2.1 Blue whale (*Balaenoptera musculus*)

Figure 3. Global distribution of blue whales (IUCN 2017).

4.2.1.1 Population Structure and Conservation Status

4.2.1.1.1 Population structure and ESA status

The blue whale is a cosmopolitan species of baleen whale (Figure 3). It was listed under the Endangered Species Conservation Act (ESCA) as endangered across its global range in 1970 (35 FR 18319) after being depleted by whaling. Congress replaced the ESCA with the ESA in 1973, and blue whales continued to be listed as endangered. A recovery plan was published in 1998 (NMFS 1998), but critical habitat has not been designated. Although blue whales have been divided into stocks for management purposes under the MMPA, distinct population segments have not been adopted under the ESA. The North Pacific population, comprised of the Central North Pacific and Eastern North Pacific stocks, occurs in Alaska.

4.2.1.1.2 Population estimate and trend

The global population of blue whales is uncertain, but based on the above information, the global total for the species is plausibly in the range 10,000-25,000, corresponding to about 3-11% of the 1911 population size (IUCN 2017). The Central North Pacific stock is estimated at 81 individuals, and insufficient data exist to assess population trends (Carretta et al. 2017). The most recent MMPA stock assessment report estimated the abundance of the Eastern North Pacific stock at 1,647 individuals; the report further determined that the population trend is uncertain and there is little evidence to support that it is increasing (Carretta et al. 2017). Another recent report estimated that the Eastern North Pacific stock is at 97% of its carrying capacity at about 2,200 animals and that density dependent factors are a key reason for the observed lack of increase in population size (Monnahan et al. 2015).

4.2.1.2 Distribution

Blue whales from the Eastern Pacific stock spend winters off Mexico, Central America, and as far as 8˚S, and feed during summer off the U.S. West Coast and to a lesser extent in the Gulf of Alaska (Carretta et al. 2017). The Central North Pacific stock spend winters in lower latitudes in the western and central Pacific, including Hawaii, and feed in summer southwest of Kamchatka, south of the Aleutians, and in the Gulf of Alaska (Carretta et al. 2017).

4.2.1.3 Natural History

Blue whales are baleen whales and the largest animals ever known to have lived on Earth. Blue whales in the Northern Hemisphere are generally smaller than those in the Southern Hemisphere. In the North Atlantic and North Pacific, they can grow up to about 90 feet (27 m); in the Antarctic, they can reach a up to about 110 feet (33 m) and can weigh more than 330,000 pounds (150,000 kg). Like other baleen whales, female blue whales are somewhat larger than males, with adults in the Antarctic reaching a maximum body length of about 33 m and weighing more than 150,000 kg.[7]

Although the populations of blue whales were severely depleted by whaling, no evidence is available to suggest that this exploitation resulted in a major change in their distribution during modern times, except perhaps in the eastern North Atlantic and the western North Pacific (NMFS 1998). It is assumed that blue whale distribution is governed largely by food requirements (krill) and that populations are seasonally migratory. Poleward movements in spring allow the whales to take advantage of high zooplankton production in summer. Movement toward the subtropics in the fall allows blue whales to reduce their energy expenditure while fasting, avoid ice entrapment in some areas, and engage in reproductive activities in warmer waters of lower latitudes (NMFS 1998).

[7] NMFS, Office of Protected Resources website, http://www.fisheries.noaa.gov/pr/species/mammals/whales/blue-whale.html, Accessed September 29, 2017.

Scientists have yet to discern many details regarding the life history of the blue whale. The best available science suggests the gestation period is approximately 10-12 months and that blue whale calves are nursed for about 6-7 months. Most reproductive activity, including births and mating, takes place during the winter. Weaning probably occurs on, or en route to, summer feeding areas. The average calving interval is believed to be two to three years, with the age of sexual maturity thought to be 5-15 years.

4.2.1.4 Vocalizations and Hearing

Calls from both populations of blue whale have been acoustically detected in the Gulf of Alaska from mid-July to mid-December, with peak occurrence from August through November (Moore et al. 2006). Calls from the eastern North Pacific population are detected from late July to mid-December, and calls from the western (now termed central) North Pacific population are detected from mid-July to mid-December (Stafford et al. 2007). More recently, two Navy-funded high frequency acoustic recording packages (HARPs) were deployed in the shelf and slope regions of north-central Gulf of Alaska and recordings were collected from July 2011 through February 2012 (Baumann-Pickering et al. 2012b). Blue whale calls were detected from both the Eastern North Pacific and Central North Pacific stocks, although calls from the latter were substantially less common. Overall, blue whale calls were detected from the start of HARP deployment in July 2011 through early January 2012, when blue whale calling decreased dramatically (Baumann-Pickering et al. 2012b).

Blue whales are in the low frequency cetaceans functional hearing group (Southall et al. 2007).

4.2.1.5 Stressors/Threats

Historically, the primary threat to blue whale populations was whaling. Collisions with vessels, entanglement in fishing gear, reduced zooplankton production due to habitat degradation, and disturbance from low-frequency noise are the most obvious potential indirect threats. Thus, unlike the more piscivorous baleen whales (e.g., the humpback whale, fin whale, minke whale, and Bryde’s whale), the blue whale in the Northern Hemisphere is probably not yet competing directly with humans for prey resources (NMFS 1998). Long term changes in climate may also affect blue whales.

Although the species is often found in coastal waters, blue whales are thought to occur generally offshore. Perhaps largely because of its offshore distribution, the blue whale seems less prone, although not immune, to lethal entanglements in fishing gear and lethal strikes by vessels (NMFS 1998). Most observed ship strikes involving blue whales have been in the southern California Bight, where shipping lanes intersect common feeding areas, and the magnitude of ship strikes likely exceeds the potential biological removal established under the MMPA of 3.1 whales per year (Carretta et al. 2017; Monnahan et al. 2015).

4.2.2 Sei whale (*Balaenoptera borealis*)

Figure 4. Global distribution of sei whales (IUCN 2017)

4.2.2.1 Population Structure and Conservation Status

The sei whale, *Balaenoptera borealis*, is a large baleen whale with a widespread distribution in all of the world's major open oceans (Kanda et al. 2006) (Figure 4). Two subspecies of sei whales have been identified but not confirmed; *B. b. schlegellii* in the southern hemisphere, and *B. b. borealis* in the northern hemisphere (Rice 1998). Empirical evidence to support classification as true subspecies is weak (Horwood 2009); however, the ranges of the northern and southern populations are not known to overlap (Rice 1998), and there are body size differences between the purported subspecies, with *B. b. schlegellii* being larger-bodied.

4.2.2.1.1 Population structure

The population structure of sei whales is not known, but is assumed to be discrete by ocean basin for *B. b. borealis* (NMFS 2011c). Currently, the IWC only recognizes one stock of sei whales in the North Pacific (NMFS 2011c). For management purposes under the MMPA, NMFS considers four stocks of sei whale, including the eastern North Pacific stock that occurs seasonally in waters off Alaska, east of 180˚ longitude.

4.2.2.1.2 Population estimate

Sei whales are estimated to have numbered greater than 105,000 worldwide prior to commercial whaling, which reduced the population to 25,000 by 1991 (Braham 1991). Sei whales in the North Pacific numbered about 49,000 whales in 1963, were reduced to 37,000-38,000 whales by 1967, and reduced again to 20,600-23,700 whales by 1973 (Ohsumi and Fukuda 1975). When commercial whaling for sei whales ended in 1974, the population in the North Pacific had been reduced to somewhere between 7,260-12,620 animals (Tillman 1977). There are insufficient data to estimate the current global population size of or trend for sei whales.[8] A recent study estimates the abundance of sei whales in the central and eastern North Pacific at 29,632 animals (Hakamada et al. 2017).

4.2.2.1.3 ESA Status

The sei whale was listed as endangered under the Endangered Species Conservation Act (ESCA) on December 2, 1970 (35 FR 18319) after commercial whaling decimated all known populations. Congress replaced the ESCA with the ESA in 1973, and sei whales continued to be listed throughout their range as endangered. To date, there has been no effort to define subspecies or DPS of sei whale under the ESA (NMFS 2011c). A final recovery plan for the sei whale was published in 2011 (NMFS 2011c). The ESA status of sei whales was reviewed in 2012 (NMFS 2012). Upon review, NMFS determined that many of the required recovery criteria had not been met and insufficient abundance data exist to delist or downlist the species' ESA status. Therefore, the sei whale continues to be listed as endangered under the ESA. Critical habitat has not been designated for the sei whale.

4.2.2.2 Distribution

Sei whales prefer subtropical, temperate, and subarctic waters, and can be found in low numbers in the Atlantic, Indian, and Pacific Oceans. Sei whales in the North Pacific have been reported primarily south of the Aleutian Islands, in Shelikof Strait and waters surrounding Kodiak Island, in the Gulf of Alaska, the inside waters of Southeast Alaska, and south to California in the east, and Japan and Korea to the west. Whaling data suggest that sei whales do not venture north of about 55°N (Gregr et al. 2000), although Horwood (1987) reported rare sightings in the Bering Sea as far north as 60°N. Historically, sei whales were common in the northern Gulf of Alaska (Calkins 1986), but recent observations of sei whales in Alaska EEZ waters of the Gulf of Alaska and along the Aleutian Island chain are rare (Hakamada et al. 2017). The migratory pattern of this species is thought to encompass long distances from high-latitude feeding areas in summer to low-latitude breeding areas in winter; however, the location of winter areas remains largely unknown (Perry et al. 1999a). Sei whales are often associated with deeper waters and areas along continental shelf edges (Hain et al. 1985). The species appears to lack a well-defined social structure, and individuals are usually found alone or in small groups of up to six whales (Perry et al. 1999a). When on feeding grounds, larger groupings have been observed (Gambell 1985b).

8 International Whaling Commission website, https://iwc.int/index.php?cID=status, accessed Sept. 8, 2017.

4.2.2.3 Natural History

Sei whales are primarily planktivorous, feeding mainly on euphausiids and copepods, although they are also known to consume fish. In the Northern Hemisphere, sei whales consume small schooling fish such as anchovies, sardines, and mackerel when locally abundant (Konishi et al. 2009). Sei whales in the North Pacific feed on euphausiids and copepods, which make up about 95% of their diet (Calkins 1986). The balance of their diet consists of squid and schooling fish, including smelt, sand lance, Arctic cod, rockfish, pollock, capelin, and Atka mackerel (Nemoto and Kawamura 1977).

4.2.2.4 Vocalizations and Hearing

There is no direct information about the hearing abilities of baleen whales, including sei whales. It is generally assumed that most animals hear well in the frequency ranges similar to those used for their vocalizations (NMFS 2011c). Data on sei whale vocalizations are limited. Recordings of sei whales in the southern hemisphere identified both downsweep and upsweep calls with frequencies between 34 and 87 Hz and with an average duration of 1.1 seconds (Calderan et al. 2014). This study corroborates earlier studies off the Hawaiian Islands (Rankin and Barlow 2007) and Cape Cod, Massachusetts (Baumgartner et al. 2008), that detected low frequency vocalizations (<100 Hz) attributed to sei whales. McDonald et al. (2005) reported sei whale calls that ranged from 200-600 Hz. It is reasonable to assume that sei whale hearing includes, and likely extends beyond, the frequencies described for these vocalizations (NMFS 2011c). Along with most other large baleen whales, sei whales are classified in the low frequency (LF) cetacean functional hearing group (Southall et al. 2007).

4.2.2.5 Stressors/Threats

Threats to sei whales include collisions with vessels, entanglement in active or derelict fishing gear, reduced or displaced prey abundance due to climate change, the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates, and the effects of increasing anthropogenic ocean noise (NMFS 2011c).

Because sei whales are more commonly located offshore and are relatively scarce in Atlantic and Pacific coastal waters, sei whales likely have a relatively low incidence of entrapment and entanglement in fishing gear (NMFS 2012). However, the potential for entanglement still exists, and some mortality of large whales may go undetected (Carretta et al. 2017). The total annual serious injury and mortality rate from fisheries interactions and ship strikes was 0 sei whales for the eastern North Pacific stock for the 2010 to 2014 period (Carretta et al. 2017).

4.2.3 Cook Inlet beluga whale (*Delphinapterus leucas*)

4.2.3.1 Population Structure, Distribution, and Conservation Status

Beluga whales are distributed throughout Arctic and subarctic waters of the northern hemisphere (Gurevich 1980). NMFS recognizes five stocks of beluga whales in Alaska, and the Cook Inlet beluga whale is a distinct population restricted to the waters of Cook Inlet, Alaska (Figure 5).

Some beluga populations migrate seasonally over long distances, but the Cook Inlet stock remains in the inlet year-round (Hobbs and Shelden 2008). Of the five stocks in U.S. waters, only the Cook Inlet stock is found south of the Alaska Peninsula; genetic analyses indicate that this stock is the most isolated of the five (O'Corry-Crowe et al. 2002).

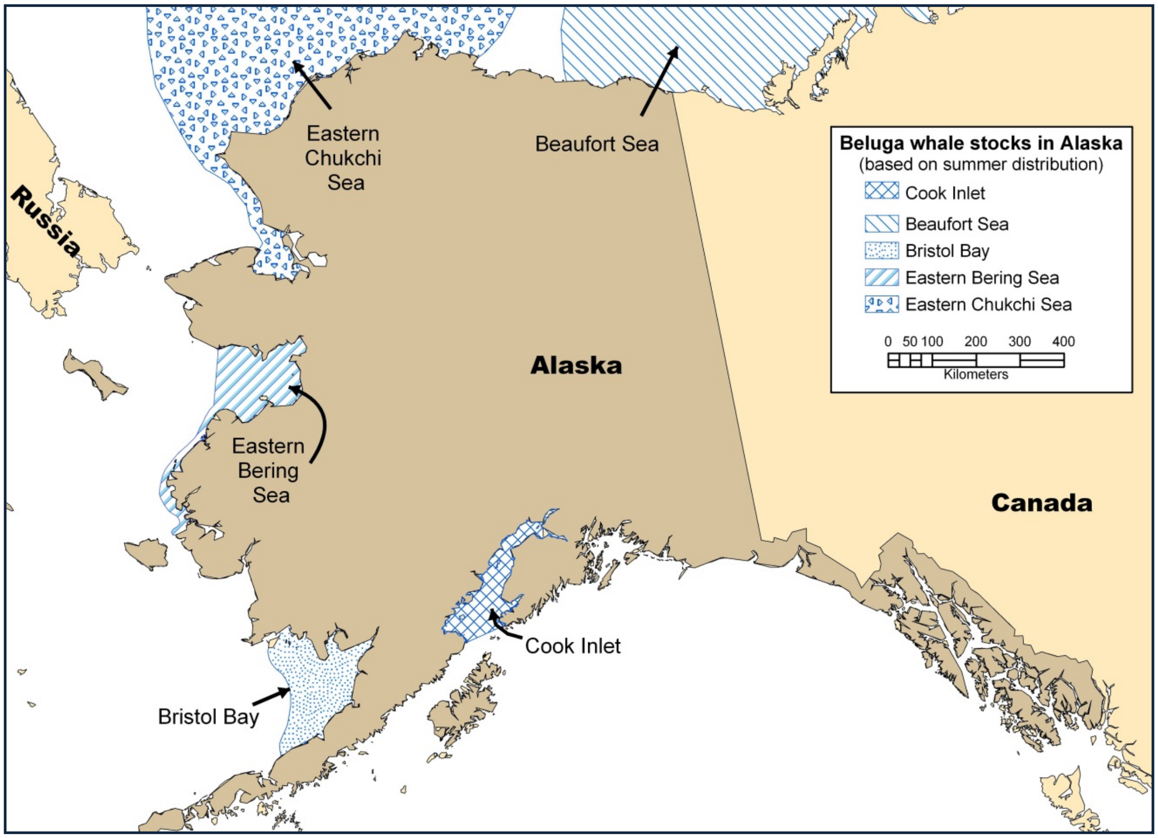

Figure 5. Map showing the range of the 5 beluga whale stocks in Alaska. The Cook Inlet beluga whale DPS is restricted to the waters of Cook Inlet.

4.2.3.1.1 Population estimate and trend

The historic Cook Inlet beluga whale population was estimated at around 1,300 whales in 1979 (Calkins 1989). Aerial surveys in the 1990s documented a nearly 50 percent decline in Cook Inlet beluga abundance from 653 whales in 1994 to 347 whales in 1998 (Hobbs et al. 2000). This decline was attributed to overharvest by subsistence hunters. Measures were established in 1999 to regulate subsistence harvests, but the population has continued to decline. The 10-year trend (2004-2014) has shown a decrease of 0.4% per year (Muto et al. 2017). The most recent aerial survey population estimate from 2016 is 328 whales (Shelden et al. 2017).

4.2.3.1.2 ESA status

NMFS listed the Cook Inlet DPS of beluga whale as endangered in 2008 (73 FR 62919; October 22, 2008) and a recovery plan was finalized in 2016 (NMFS 2016f). Critical habitat was designated in 2011 (76 FR 20180; April 11, 2011).

4.2.3.2 Critical Habitat

Critical habitat for Cook Inlet belugas includes two areas of marine habitat in Cook Inlet that comprise 7,800 km^2, excluding waters near the Port of Anchorage (Figure 6). Cook Inlet beluga whale critical habitat contains the following physical or biological features that NMFS determined are essential to the conservation of the DPS:

1) Intertidal and subtidal waters of Cook Inlet with depths less than 30 feet (MLLW) and within 5 miles of high and medium flow anadromous fish streams;

2) primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock (*Gadus chalcogrammus*), saffron cod, and yellowfin sole;

3) waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales;

4) unrestricted passage within or between the critical habitat areas; and

5) waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales.

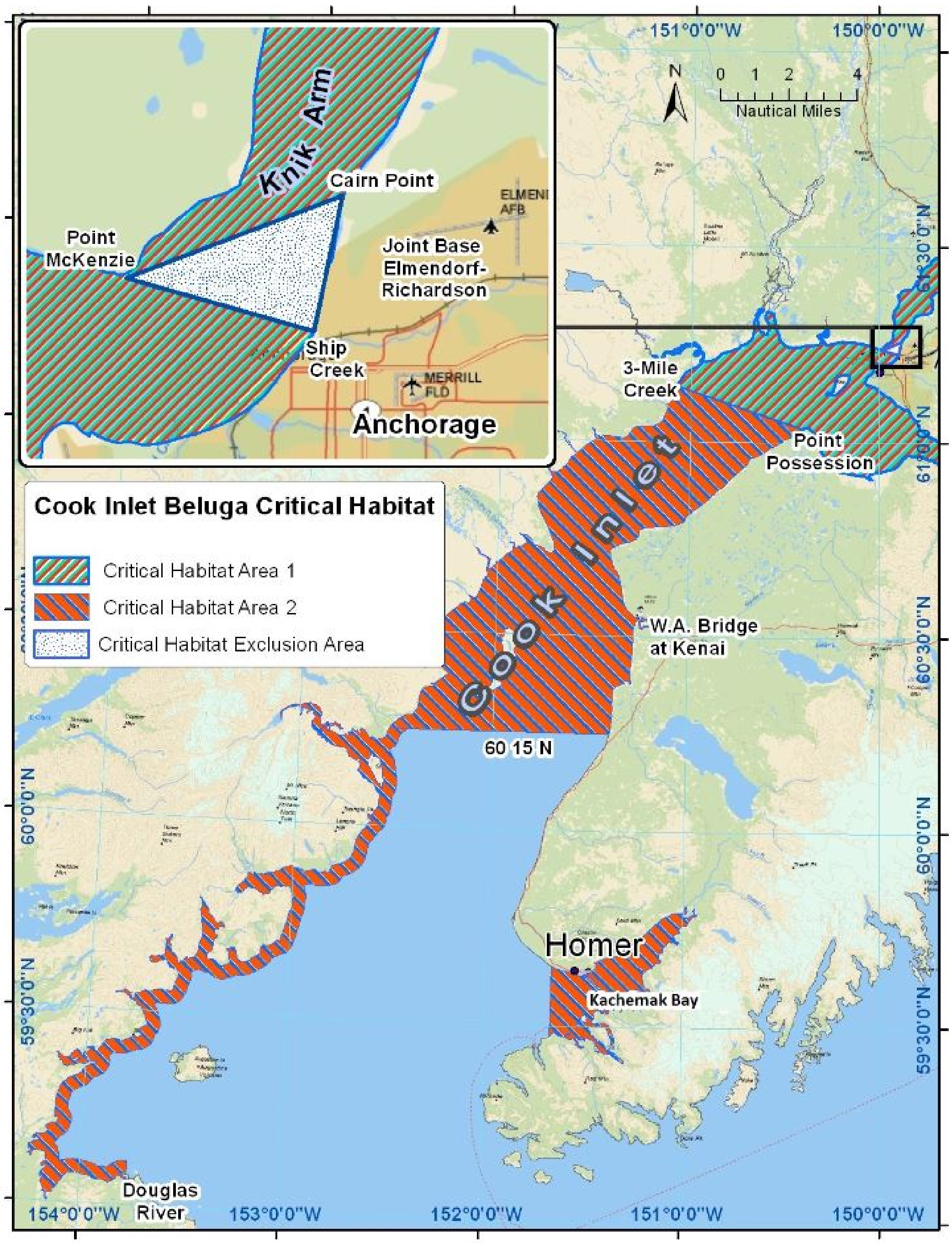

Figure 6. Designated critical habitat for the Cook Inlet beluga whale.

Critical Habitat Area 1 (Figure 6) encompasses 1,909 km^2 of Cook Inlet northeast of a line from the mouth of Threemile Creek to Point Possession, including portions of the Susitna, Little Susitna, and Chickaloon Rivers. The area contains shallow tidal flats and river mouths or estuarine areas, and it is important for foraging and calving. Mudflats and shallow areas adjacent to medium and high flow accumulation streams may also provide for other biological needs, such as molting or escape from predators (Shelden et al. 2003). Area 1 also has the highest density of beluga whales from spring through fall as well as the greatest potential for adverse impact from anthropogenic threats.

Many rivers in Area 1 habitat have large eulachon and salmon runs. Two such rivers in Turnagain Arm, Twentymile River and Placer River, are visited by beluga whales in early spring, indicating the importance of eulachon runs for beluga whale feeding. Beluga whale use of upper Turnagain Arm decreases in the summer and then increases again in August through the fall, coinciding with the coho salmon run. Intensive summer feeding by beluga whales occurs in the Susitna Delta area, Knik Arm, and Turnagain Arm.

Satellite telemetry data and long-term aerial survey data demonstrate beluga whales use Knik Arm year around, often entering and leaving the Arm on a daily basis (Hobbs et al. 2005; Rugh et al. 2005). These surveys demonstrate high use of the Susitna Delta area (from the Little Susitna River to Beluga River) and Chickaloon Bay (Turnagain Arm), with frequent large scale movements between the delta area, Knik Arm, and Turnagain Arm.

Beluga whales are particularly vulnerable to impacts in Area 1 due to their high seasonal densities in Area 1 and the biological importance of the area. Because of their high use of this area (e.g., foraging, nursery, predator avoidance), activities that restrict or deter use of or access to Area 1 habitat could reduce beluga whale calving success, impair their ability to secure prey, and increase their susceptibility to predation by killer whales. Activities that reduce anadromous fish runs could also negatively impact beluga whale foraging success, thereby reducing their fitness, survival, and recovery. Furthermore, the tendency for beluga whales to occur in high concentrations in Area 1 habitat predisposes them to harm from such events as oil spills.

Critical Habitat Area 2 (Figure 6) consists of 5,891 km^2 of less concentrated spring and summer beluga whale use, but known fall and winter use areas. It is located south of Area 1, and includes nearshore areas along the west side of the Inlet and Kachemak Bay on the east side of the lower inlet. Area 2 is largely based on dispersed fall and winter feeding and transit areas in waters where whales typically occur in smaller densities or deeper waters. It includes both near and offshore areas of the mid and upper Inlet, and nearshore areas of the lower Inlet. Due to the role of this area for probable fall feeding, Area 2 includes Tuxedni, Chinitna, and Kamishak Bays on the west coast and a portion of Kachemak Bay on the east coast. Based on tracking data, important winter habitat concentration areas reach south of Kalgin Island (Hobbs et al. 2005).

4.2.3.3 Natural History

Beluga whales are relatively small (3.7 to 4.3 meters in length) odontocete whales in the Family Monodontidae. Beluga whales mate in the spring, usually in March or April, in small bays and estuaries. Gestation lasts about 14-15 months, and calves are born between March and September, mostly between May and July. Females give birth to single calves (on rare occasion, twins) every two to three years. Beluga calves nurse for at least 12 to 18 months, until their teeth emerge, at which point they supplement their diets with shrimp and small fishes. Most calves continue to nurse for another year after beginning to eat solid food. Female belugas begin to reproduce at 4 to 7 years of age and males at 7 to 9 years. Their lifespan is thought to be 35-50 years.

Although Cook Inlet beluga whales remain within the waters of Cook Inlet, seasonal patterns may exist in their annual movements within the inlet. During spring and summer months, Cook Inlet belugas are generally concentrated near river mouths in northern Cook Inlet (Rugh et al. 2010). Cook Inlet belugas may range more widely within the inlet in winter months, but their winter distribution is not well known (Allen and Angliss 2014).

Cook Inlet belugas feed on a wide variety of prey species, focusing on specific species when they are seasonally abundant. In the spring, eulachon and gadids are preferred prey (Hobbs and Shelden 2008). From late-spring and through summer, the majority of beluga stomachs contained Pacific salmon coincident with the timing of fish runs in the area (Hobbs and Shelden 2008). In the fall, as salmon runs begin to decline, belugas consume the fish species found in nearshore bays and estuaries. This includes cod species observed in the spring diet as well as other bottom-dwellers: Pacific staghorn sculpin and flatfishes such as starry flounder and yellowfin sole (Hobbs and Shelden 2008). Although diet information is not available for winter months, data from belugas tagged with satellite transmitters suggest that during the winter whales are feeding in deeper waters (Hobbs et al. 2005), possibly on such prey species as flatfish, cod, sculpin, and pollock.

Cook Inlet belugas are gregarious and are often found in pods of over 10 individuals. They have excellent hearing, acute vision, and are very vocal (Hobbs and Shelden 2008). Belugas use acoustic signals to communicate, navigate, locate prey, and sense their environment (Richardson et al. 1995a). Anthropogenic noise has the potential to disrupt the behavior and even injure Cook Inlet belugas.

4.2.3.4 Vocalizations and Hearing

Like other odontocetes, beluga whales produce sounds for two overlapping functions: communication and echolocation. For their social interactions, belugas emit communication calls with an average frequency range of about 0.2 to 7.0 kHz (Garland et al. 2015), well within the human hearing range, and the variety of audible whistles, squeals, clucks, mews, chirps, trills, and bell-like tones they produce have led to their nickname as sea canaries. At the other end of their hearing range, belugas use echolocation signals (biosonar) with peak frequencies at 40-120 kHz (Au 2000) to navigate and hunt in dark or turbid waters, where vision is limited. Belugas and other odontocetes make sounds across some of the widest frequency bands that have been measured in any animal group. Beluga whales are in the mid-frequency (MF) cetacean functional hearing group (Southall et al. 2007).

Even among odontocetes, beluga whales are known to be among the most adept users of sound. It is possible that the beluga whale’s unfused vertebrae, and thus the highly movable head, have allowed adaptations for their sophisticated directional hearing. Awbrey et al. (1988) examined their hearing in octave steps between 125 Hz and 8 kHz, and found average hearing thresholds of 121 dB re1 μPa at 125 Hz and 65 dB re 1 μPa at 8 kHz. Johnson et al. (1989), further examining beluga hearing at frequencies between 40 Hz and 125 kHz, found a hearing threshold of 140 dB re 1 μPa at 40 Hz. The lowest measured threshold (81 dB re 1 μPa) was at 4 kHz. Ridgway et al. (2001) measured hearing thresholds at various depths down to 984 ft (298 m) at frequencies between 500 Hz and 100 kHz and found that beluga whales showed unchanged hearing sensitivity at any measured depth. Finneran et al. (2005) described the auditory ranges of two belugas as 2 kHz to 130 kHz. Most of these studies measured beluga hearing in very quiet conditions. However, in Cook Inlet, tidal currents regularly produce ambient sound levels well above 100 dB (Lammers et al. 2013). Belugas' signal intensity can change with location and background noise levels (Au et al. 1985). In the first report of hearing ranges of belugas in the wild, results of Castellote et al. (2014) were similar to those reported for captive belugas, with most acute hearing at middle frequencies, about 10-75 kHz.

4.2.3.5 Stressors/Threats

Natural and anthropogenic sources of stress, injury, and mortality to Cook Inlet beluga whales are discussed extensively in the Recovery Plan (NMFS 2016f) and are summarized below.

4.2.3.5.1 Fisheries Interactions

Only one known Cook Inlet beluga whale mortality can be attributed to commercial fishery interactions within the past 10 years (Muto et al. 2017). NMFS placed observers in the Cook Inlet salmon drift and gillnet fisheries in 1999 and 2000 to monitor interactions and recorded no fishery-related injuries or mortalities (Manly 2006).

NMFS has only documented one Cook Inlet beluga mortality that was associated with personal use, subsistence, or recreational fisheries (Burek-Huntington et al. 2015). This was a case in which a sick juvenile beluga became entangled and subsequently drowned in a subsistence set net.

4.2.3.5.2 Subsistence hunting

Subsistence harvest of beluga whales in Cook Inlet has been important to the village of Tyonek and the subsistence hunting community in Anchorage. Since the hunt moratorium was implemented in 1999, 5 whales have been authorized for subsistence harvest, and no whales have been harvested for subsistence since 2005 (Muto et al. 2017). A long term harvest plan[9] was adopted in 2008 (73 FR 60976; October 15, 2008) that established allowable harvest levels for 5-year periods, based on the average abundance in the previous 5-year period and the growth rate over the previous 10-year period. Under this plan, no harvest is allowed if the previous 5-year average abundance is less than 350 belugas. Because the 5-year average abundances have remained below 350 whales, no harvest has been allowed in recent years (Muto et al. 2017).

[9] Available at https://alaskafisheries.noaa.gov/pr/cib-long-term-harvest-management, Accessed Sept. 12, 2017.

4.2.3.5.3 Live strandings

Mortality related to live stranding events, where a group of whales becomes stranded as the tide recedes, has been reported in Cook Inlet (Muto et al. 2017). The majority of live stranding events for Cook Inlet belugas occur in the shallow bays of Turnagain Arm and Knik Arm (NMFS 2016f) Although many of these observed stranded individuals are expected to return to sea with the incoming tide and survive, some mortalities are documented while others are likely missed by observers, including whales that may die later of stranding-related injuries (Burek-Huntington et al. 2015; Vos and Shelden 2005). Between 1988 and 2016, 214 dead Cook Inlet belugas were reported and at least 876 belugas were involved in live strandings in Cook Inlet (NMFS 2016f).

4.2.3.5.4 Predation

The only known predator of Cook Inlet belugas is the transient (mammal-eating) killer whale; however, it is possible that sharks may also prey on belugas (NMFS 2016f). Killer whale sightings are rare in the upper inlet, and 9-12 beluga deaths have been attributed to killer whale predation between 1982 and 2016 (NMFS 2016f). Killer whales may also prompt some live strandings of Cook Inlet beluga whales.

4.2.3.5.5 Other Stressors

The restricted range of the Cook Inlet beluga and its proximity to Alaska's human population center of Anchorage make this DPS vulnerable to both direct and incidental mortalities and injuries caused by human and natural perturbations (Hobbs and Shelden 2008; Moore et al. 2000a; NMFS 2016f). These include:

- Poaching or intentional harassment
- Vessel strikes
- Habitat alteration
- Oil and gas exploration and development, including 3-D seismic surveys
- Expansion and improvements to the Port of Anchorage
- Research activities
- Marine debris
- Contaminants (e.g., oil spills, urban runoff)
- Changes in prey availability due to natural environmental variability, ocean acidification, and commercial fisheries
- Climatic changes affecting habitat
- Noise
- Construction activities
- Other physical habitat modifications that may occur as Cook Inlet becomes increasingly urbanized

4.2.4 Fin whale (*Balaenoptera physalus*)

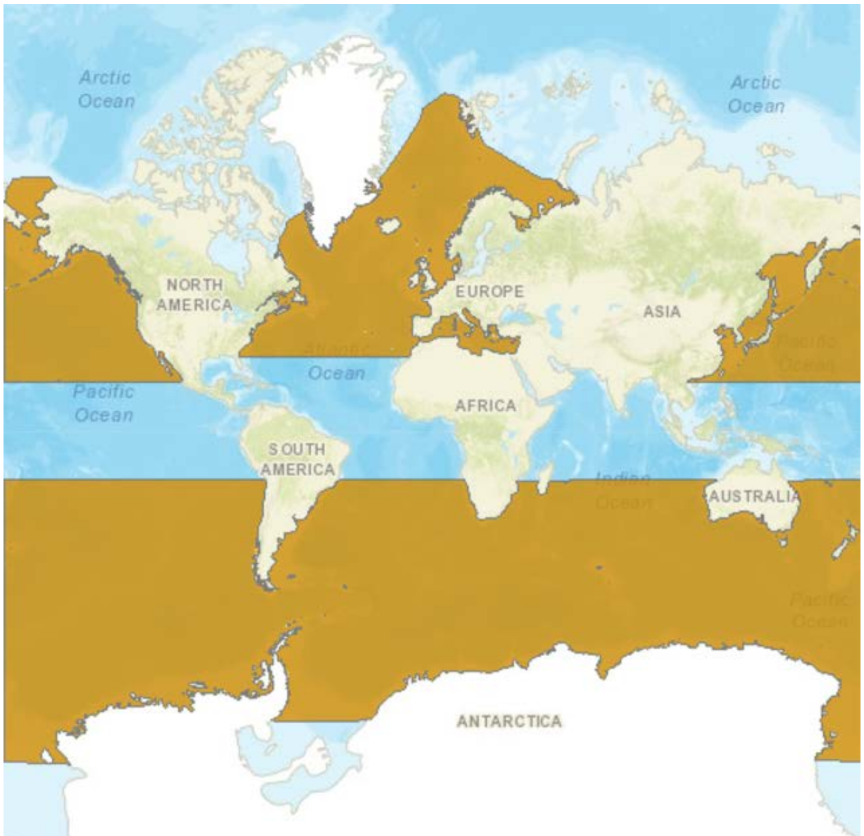

Figure 7. Global distribution of fin whales (IUCN 2017).

4.2.4.1 Population Structure and Conservation Status

4.2.4.1.1 Population structure

Fin whales occur worldwide, mainly (but not exclusively) in offshore waters. They are rare in the tropics, except in certain cool-water areas, such as off Peru (IUCN 2017)(Figure 7). There are two named subspecies of fin whale: *B. p. physalus* in the North Atlantic Ocean, and *B. p. quoyi* in the Southern Ocean. Most experts consider fin whales in the North Pacific to also be part of a separate, unnamed subspecies.

There is still insufficient information to accurately determine population structure for fin whales (Carretta et al. 2017). The IWC recognizes seven stocks of fin whales in the North Atlantic Ocean and two in the North Pacific (East China Sea and the rest of the North Pacific). However, histological samples and tagging experiments suggest that there are five possible stocks of fin whales in the North Pacific: (1) East and West Pacific that intermingle around the Aleutian Islands, (2) East China Sea, (3) British Columbia, (4) Southern-Central California to Gulf of Alaska, and (5) Gulf of California (Mizroch et al. 1984). Under the MMPA, NMFS manages three stocks of fin whale in the North Pacific: (1) the Hawaii stock; (2) the

California/Oregon/Washington stock, and (3) the Alaska stock (Carretta et al. 2017). NMFS also manages the Western North Atlantic Stock off the East Coast of the United States.

4.2.4.1.2 ESA status

NMFS listed the entire species of fin whale rangewide as endangered in 1970 (35 FR 18319) following large scale declines due to commercial whaling. Congress replaced the ESCA with the ESA in 1973, and fin whales continued to be listed throughout their range as endangered. A recovery plan was prepared in 2010 (NMFS 2010d). Critical habitat has not been designated for this species.

4.2.4.1.3 Population estimate and trend

Prior to exploitation by commercial whalers, fin whales are thought to have numbered greater than 464,000 worldwide, and are now thought to number approximately 119,000 worldwide (Braham 1991). Although reliable and recent estimates of fin whale abundance are available for large portions of the North Atlantic Ocean, this is not the case for most of the North Pacific Ocean or for the Southern Hemisphere (NMFS 2010d). Indeed, no reliable global population estimate for fin whales exists. For the Hawaii stock the best abundance estimate is 58 whales, and no data are available on the population trend for this stock (Carretta et al. 2017). The best estimate for the Northeast Pacific stock is 1,368 whales; the trend appears to be increasing since at least 2002 (Friday et al. 2013), but the true magnitude of that increase is uncertain (Carretta et al. 2017). The California/Oregon/Washington stock is estimated at 9,029 whales with evidence for an increasing trend (Carretta et al. 2017).

4.2.4.2 Distribution

Fin whales are found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes, and are less common in the tropics. They occur year-round in a wide range of latitudes and longitudes, but the density of individuals in any one area changes seasonally.

In the North Pacific Ocean, fin whales occur in summer foraging areas in the Chukchi Sea, the Sea of Okhotsk, around the Aleutian Islands, and the Gulf of Alaska (Figure 8); in the eastern Pacific, they occur south to California; in the western Pacific, they occur south to Japan. Fin whales in the eastern Pacific winter from California south; in the western Pacific, they winter from the Sea of Japan, the East China, Yellow, and Philippine Seas (Gambell 1985a).

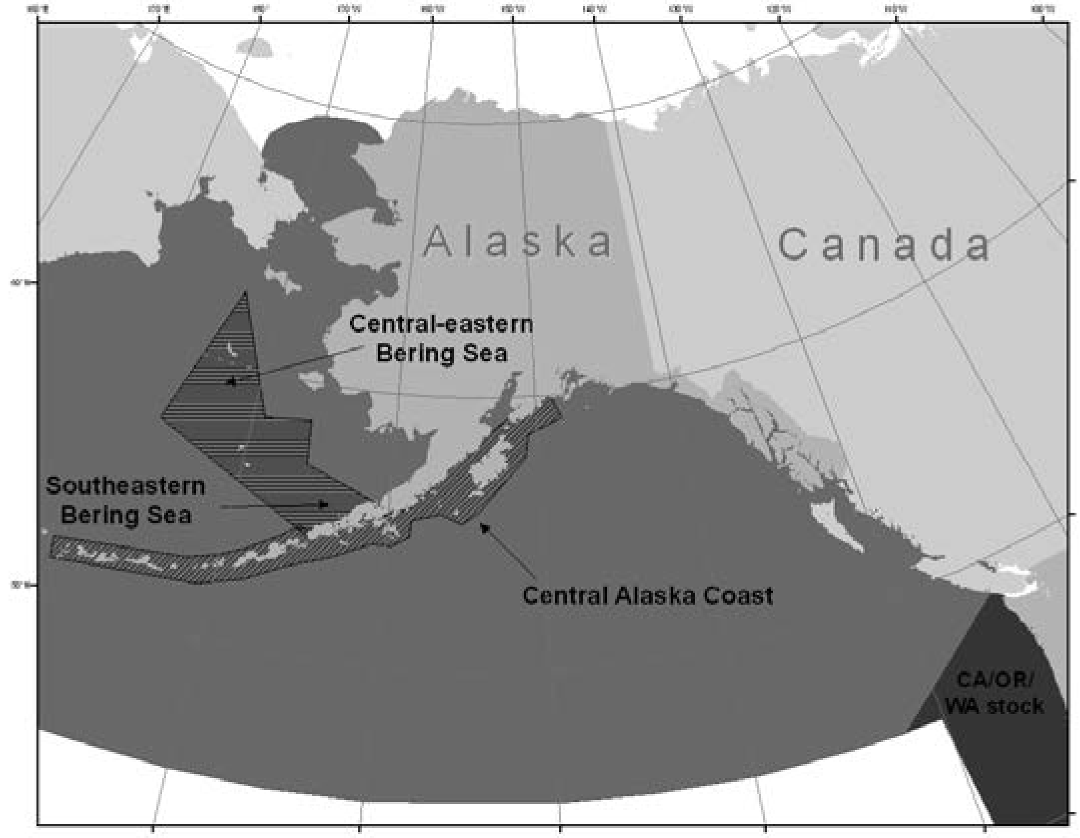

Figure 8. Approximate distribution of fin whales in the eastern North Pacific Ocean (shaded area) (Muto et al. 2017). Striped areas indicate where vessel surveys occurred in 1999-2000 (Moore et al. 2002) and 2001-2003 (Zerbini et al. 2006).

4.2.4.3 Natural History

In the North Pacific, fin whales' preferred prey is euphausiids (mainly *Euphausia pacifica*, *Thysanoessa longipes*, *T. spinifera*, and *T. inermis*) and large copepods (mainly *Calanus cristatus*), followed by schooling fish such as herring, walleye pollock, and capelin (Nemoto 1970).

4.2.4.4 Vocalizations and Hearing

Fin whales produce a variety of low-frequency sounds in the 10-200 Hz band (Thompson et al. 1992). The most typical signals are long, patterned sequences of short duration (0.5-2 second) infrasonic pulses in the 18-35 Hz range (Patterson and Hamilton 1964). Estimated source levels for fin whales are 140-200 decibels re 1 µPa at 1 meter (Clark and Gagnon 2004; Patterson and Hamilton 1964; Thompson et al. 1992). Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Ketten 1997; Richardson et al. 1995a).

Fin whales are in the low frequency (LF) cetacean functional hearing group (Southall et al. 2007).

4.2.4.5 Stressors/Threats

Populations in the North Atlantic, North Pacific, and Southern Hemisphere have been legally protected from commercial whaling for the last thirty or more years, and this protection continues. Although the main direct threat to fin whales was addressed by the IWC moratorium on commercial whaling, several potential threats remain. Among the current potential threats are collisions with vessels, entanglement, reduced prey abundance due to overfishing and or climate change, the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates, and possibly, the effects of increasing anthropogenic ocean noise (NMFS 2010d). Climate change may also result in range extension and reductions in sea ice may allow increased shipping in higher latitudes, as well expanded oil and gas activities in the Chukchi and Beaufort seas.

4.2.4.5.1 Fisheries Interactions and Entanglements

Between 2010 and 2014, one Northeast Pacific fin whale was reported entangled in fishing gear, resulting in a mean annual mortality rate from commercial fishing of 0.2 fin whales (Muto et al. 2017) in Alaska.

4.2.4.5.2 Vessel collisions

Between 2010 and 2014, two Northeast Pacific fin whales were fatally struck by vessels, resulting in a mean annual mortality rate from ship strikes of 0.4 fin whales (Muto et al. 2017) in Alaska.

4.2.4.5.3 Unusual Mortality Event (UME)

In 2015, NMFS declared a UME for large whales in the western Gulf of Alaska that included 11 fin whales, 14 humpback whales, 1 gray whale, and 4 unidentified cetaceans. No specific cause for the increased mortality has been identified (Muto et al. 2017).

4.2.5 Humpback whale (*Megaptera novaeangliae*)

4.2.5.1 Population Structure and Conservation Status

The humpback whale was listed as endangered under the ESCA on December 2, 1970 (35 FR 18319). Congress replaced the ESCA with the ESA in 1973, and humpback whales continued to be listed as endangered. NMFS recently conducted a global status review and changed the status of humpback whales under the ESA. The globally listed species was divided into 14 DPSs, four of which are endangered, one is threatened, and the remaining 9 are not listed under the ESA (81 FR 62260; September 8, 2016).

Three humpback whale DPSs occur in Alaska waters. The Hawaii DPS is no longer listed as endangered or threatened, the Mexico DPS is listed as threatened, and the Western North Pacific

DPS is listed as endangered. Critical habitat has not been designated for the Western North Pacific or Mexico DPSs.

Wade et al. (2016) analyzed humpback whale movements throughout the North Pacific Ocean between winter breeding areas and summer feeding areas, using a comprehensive photo-identification study of humpback whales in 2004-2006 during the SPLASH project (Structure of Populations, Levels of Abundance and Status of Humpbacks). A multi-strata mark recapture model was fit to the photo-identification data using a six-month time-step, with the four winter areas and the six summer areas defined to be the sample strata. The four winter areas corresponded to the four North Pacific DPSs: Western North Pacific (WNP), Hawaii, Mexico, and Central America. The analysis was used to estimate abundance within all sampled winter and summer areas in the North Pacific, as well as to estimate migration rates between these areas. The probability of encountering whales from each of the four North Pacific DPSs in various feeding areas is summarized in Table 9 below (NMFS 2016e).

Table 9. Probability of encountering humpback whales from each DPS in the North Pacific Ocean (columns) in various feeding areas (on left). Adapted from Wade et al. (2016).

Summer Feeding Areas	North Pacific Distinct Population Segments			
	Western North Pacific DPS (endangered)[1]	Hawaii DPS (not listed)	Mexico DPS (threatened)	Central America DPS (endangered)[1]
Kamchatka	100%	0%	0%	0%
Aleutian I/Bering/Chukchi	4.4%	86.5%	11.3%	0%
Gulf of Alaska	0.5%	89%	10.5%	0%
Southeast Alaska / Northern BC	0%	93.9%	6.1%	0%
Southern BC / WA	0%	52.9%	41.9%	14.7%
OR/CA	0%	0%	89.6%	19.7%

[1]For the endangered DPSs, these percentages reflect the 95% confidence interval of the probability of occurrence in order to give the benefit of the doubt to the species and to reduce the chance of underestimating potential takes.

4.2.5.1.1 Population estimates

The WNP DPS is endangered, and is comprised of approximately 1,107 (CV=0.3) animals (Muto et al. 2017). The population trend for the WNP DPS is unknown. Humpback whales in the WNP DPS remain rare in some parts of their former range, such as the coastal waters of Korea, and have shown little signs of recovery in those locations.

The Mexico DPS is threatened, and is comprised of approximately 3,264 (CV=0.06) animals (Wade et al. 2016) with an unknown population trend, though unlikely to be in decline (81 FR 62260, 62305; September 8 ,2016).

The Hawaii DPS is not listed under the ESA, and is estimated to be comprised of 10,103 (CV=0.3) animals (Muto et al. 2017). The population trend for the Hawaii DPS is estimated to be increasing at a rate of between 5.5 and 6.0 percent (Calambokidis et al. 2008).

Whales from these three DPSs overlap on feeding grounds off Alaska. All waters off the coast of Alaska may contain ESA-listed humpbacks. Critical habitat has not been designated for the WNP or Mexico DPSs (NMFS 2016e).

4.2.5.2 Distribution

Humpback whales are found in all ocean basins worldwide, and typically occur in tropical and subtropical waters during the winter and migrate seasonally to high latitudes during the summer to feed (Allen and Angliss 2014)(see Figure 9). An exception to this generality is that a number of humpbacks have been observed over-wintering in certain areas of Alaska, including Prince William Sound, where they take advantage of winter/spring herring runs (J. Moran, pers. comm. April 28, 2016; see also http://www.afsc.noaa.gov/Quarterly/CurrentIssue/tocABL.htm). In their summer foraging areas and winter calving areas, humpback whales tend to occupy shallower, coastal waters. However, during their seasonal migrations, humpback whales disperse widely in deep, pelagic waters and tend to avoid shallower coastal waters (Winn and Reichley 1985).

Relatively high densities of humpback whales occur throughout much of Southeast Alaska and northern British Columbia, particularly during the summer months (Allen and Angliss 2015). The abundance estimate for humpback whales in the Southeast Alaska is estimated to be 6,137 (CV= 0.07) animals, which includes whales from the Hawaii DPS (~94%) and Mexico DPS (~6%) (Wade et al. 2016). Although migration timing varies among individuals, most whales depart for Hawaii or Mexico in fall or winter and begin returning to Southeast Alaska in spring, with continued returns through the summer and a peak occurrence in Southeast Alaska during late summer to early fall. However, there are significant overlaps in departures and returns (Baker et al. 1985; Straley 1990). Humpback whales in the Gulf of Alaska number between 1,755 and 2,487 animals.

Humpback whales have been observed throughout much of the shelf waters (waters over the continental shelves) of the Bering Sea, but densities of humpbacks appear relatively low in the northern shelf area, with relatively few sightings north of St. Lawrence Island (Friday et al. 2013; Moore et al. 2002; Moore et al. 2000b). Humpback whales are consistently concentrated in coastal waters north of Unimak Pass (Friday et al. 2012). In the Aleutian Islands, there are high densities of humpback whales in the eastern Aleutians, but the densities decline in the western Aleutian Islands (Zerbini et al. 2006). Interchange was seen during the SPLASH project between the eastern Aleutians and the Bering Sea, and there were no genetic differences between the areas (Baker et al. 2013).

Humpback whales have also been observed during the summer in the Chukchi and Beaufort Seas (Allen and Angliss 2015). In August 2007, a mother-calf pair was sighted from a barge approximately 87 km (54.1 mi) east of Barrow in the Beaufort Sea (Hashagen et al. 2009). Additionally, Ireland et al. (2008) reported three humpback sightings in 2007 and one in 2008 during surveys of the eastern Chukchi Sea.

During vessel-based surveys in the Chukchi Sea, Hartin et al. (2013) reported four humpback whales in 2007, two in 2008, and one in 2010. Five humpback sightings (11 individuals) occurred during the CSESP vessel-based surveys in 2009 and 2010 (Aerts et al. 2012), and a single humpback was observed several kilometers west of Barrow during the 2012 Chukchi Sea Environmental Studies Program vessel-based survey (Aerts et al. 2013).

The Aerial Surveys of Arctic Marine Mammals (ASAMM) reported four humpback whale sightings near the coast between Icy Cape and Pt. Barrow in July and August of 2012, as well as 24 individual humpback whales on September 11, 2012, south and east of Pt. Hope (Clarke et al. 2013). Prior to 2012 only a single humpback had been sighted during the Chukchi Offshore Monitoring in Drilling Area Survey (Clarke et al. 2011b).

Humpback whales have been seen and heard with some regularity in recent years (2009-2012) in the southern Chukchi Sea, often feeding and in very close association with feeding gray whales. Sightings have occurred mostly in September, but effort in the southern Chukchi has not been consistent and it is possible that humpback whales are present earlier than September (Clarke et al. 2011b; Crance et al. 2011; Hashagen et al. 2009). Additional sightings of four humpback whales occurred in 2009 south of Point Hope, while transiting to Nome (Brueggeman 2010).

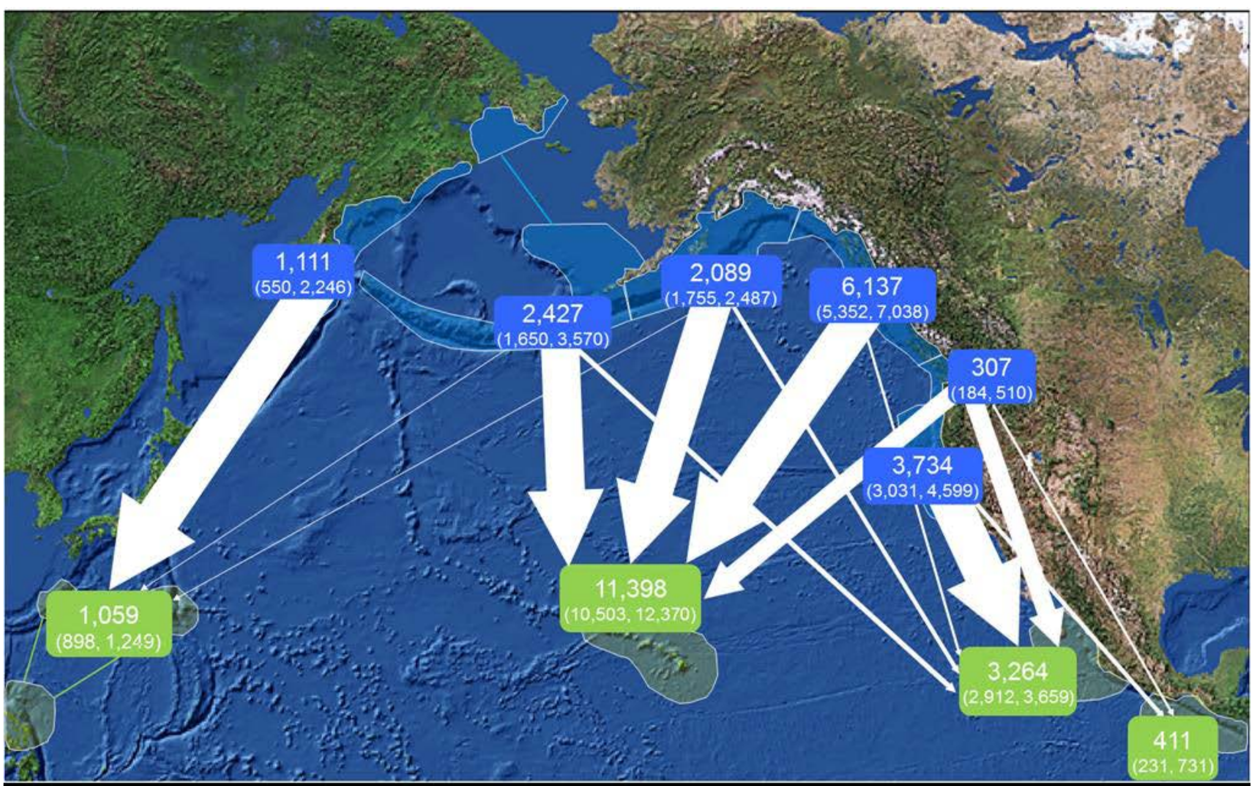

Figure 9. Abundance by summer feeding areas (blue), and winter breeding areas (green), with 95% confidence limits in parentheses. Migratory destinations from feeding area to breeding area are indicated by arrows with width of arrow proportional to the percentage of whales moving into winter breeding area (Wade et al. 2016).

4.2.5.3 Natural History

4.2.5.3.1 Reproduction and Growth

Humpbacks give birth and presumably mate on low-latitude wintering grounds in January to March in the Northern Hemisphere. Females attain sexual maturity at 5 years in some populations and exhibit a mean calving interval of approximately two years (Barlow and Clapham 1997; Clapham 1992). Gestation is about 12 months, and calves probably are weaned by the end of their first year (Perry et al. 1999b).

Although long-term relationships do not appear to exist between males and females, mature females do pair with other females; those individuals with the longest standing relationships also have the highest reproductive output, possibly as a result of improved feeding cooperation (Ramp et al. 2010).

4.2.5.3.2 Feeding and Prey Selection

Humpback whales tend to feed on summer grounds and not on winter grounds. However, some opportunistic winter feeding has been observed at low latitudes (Perry et al. 1999b). Humpback whales engulf large volumes of water and then filter small crustaceans and fish through their fringed baleen plates.

Humpback whales are relatively generalized in their feeding compared to some other baleen whales. In the Northern Hemisphere, known prey includes: euphausiids (krill); copepods; juvenile salmonids; Arctic cod; walleye pollock; pteropods; and cephalopods (Johnson and Wolman 1984; Perry et al. 1999b). Foraging is confined primarily to higher latitudes (Stimpert et al. 2007).

4.2.5.3.3 Diving and Social Behavior

In Hawaiian waters, humpback whales remain almost exclusively within the 1800 m isobath and usually within water depths less than 182 meters. Maximum diving depths are approximately 170 m (558 ft) (but usually <60 m [197 ft]), with a very deep dive (240 m [787 ft]) recorded off Bermuda (Hamilton et al. 1997). They may remain submerged for up to 21 minutes (min) (Dolphin 1987a). Dives on feeding grounds ranged from 2.1-5.1 min in the north Atlantic (Goodyear unpublished manuscript); whales observed feeding on Stellwagen Bank dove <40 m (Hain et al. 1995). In southeast Alaska average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales, with the deepest dives to 148 m (Dolphin 1987a). Because most humpback prey is likely found above 300 m depths, most humpback dives are probably relatively shallow. Hamilton et al. (1997) tracked one possibly feeding whale near Bermuda to 240 m depth.

In a review of the social behavior of humpback whales, Clapham (1996) reported that they form small, unstable social groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long periods of time. There is good evidence of some territoriality on feeding grounds (Clapham 1994; Clapham 1996) and calving areas (Tyack 1981). In calving areas, males sing long complex songs directed towards females, other males, or both. The breeding season can best be described as a floating lek or male dominance polygyny (Clapham 1996). Inter-male competition for proximity to females can be intense as expected by the sex ratio on the breeding grounds, which may be as high as 2.4:1.

4.2.5.4 Vocalization and Hearing

While there is no direct data on hearing in low-frequency cetaceans, the functional hearing range is anticipated to be between 7 Hz to 35 kHz (Au et al. 2006; Ciminello et al. 2012; NMFS 2016g; Southall et al. 2007; Watkins 1986). Baleen whales have inner ears that appear to be specialized for low-frequency hearing. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing.

Humpback whales produce a wide variety of sounds ranging from 20 Hz to 10 kHz. During the breeding season males sing long, complex songs, with frequencies in the 20-5000 Hz range and intensities as high as 181 dB (Payne 1970; Thompson et al. 1986; Winn et al. 1970). Source levels average 155 dB and range from 144 to 174 dB (Thompson et al. 1979). The songs appear to have an effective range of approximately 10 to 20 km. Animals in mating groups produce a variety of sounds (Silber 1986b; Tyack 1981).

Social sounds in breeding areas associated with aggressive behavior in male humpback whales are very different than songs and extend from 50 Hz to 10 kHz (or higher), with most energy in components below 3 kHz (Silber 1986a; Tyack and Whitehead 1983). These sounds appear to have an effective range of up to 9 km (Tyack and Whitehead 1983).

Humpback whales produce sounds less frequently in their summer feeding areas. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2-0.8 seconds and source levels of 175-192 dB (Thompson et al. 1986). These sounds are attractive and appear to rally animals to the feeding activity (D'Vincent et al. 1985; Sharpe and Dill 1997).

In summary, humpback whales produce at least three kinds of sounds:

1. Complex songs with components ranging from at least 20 Hz–24 kHz with estimated source levels from 144– 174 dB; these are mostly sung by males on the breeding grounds (Au et al. 2006; Au et al. 2000; Frazer and Mercado 2000; Richardson et al. 1995a; Winn et al. 1970);

2. Social sounds in the breeding areas that extend from 50Hz – more than 10 kHz with most energy below 3kHz (Richardson et al. 1995a; Tyack and Whitehead 1983); and

3. Feeding area vocalizations that are less frequent, but tend to be 20 Hz–2 kHz with estimated sources levels in excess of 175 dB re 1 Pa at 1m (Richardson et al. 1995a; Thompson et al. 1986).

Humpback whales are in the low frequency (LF) cetacean function hearing group (Southall et al. 2007).

4.2.5.5 Stressors/Threats

The MMPA stock delineations have not yet been revised to correspond with the 14 DPSs established under the ESA for humpback whales in 2016. Therefore, estimates of rates of mortality and serious injury in the MMPA stock assessment reports (SARs) do not correspond exactly with individual DPSs under the ESA. A general description of threats and stressors to all humpback whales occurring in Alaska is provided below. Please refer to the SARs for more information about rates of mortality and serious injury by MMPA stock (Carretta et al. 2017; Muto et al. 2017).

4.2.5.5.1 Commercial Whaling

Historically, commercial whaling represented the greatest threat to every population of humpback whales and was ultimately responsible for listing humpback whales as an endangered species. From 1900 to 1965, nearly 30,000 whales were taken in modern whaling operations of the Pacific Ocean. Prior to that, an unknown number of humpback whales were taken (Perry et al. 1999b). In 1965, the International Whaling Commission banned commercial hunting of humpback whales in the Pacific Ocean.

4.2.5.5.2 Predation

Humpback whales are killed by orcas (Dolphin 1987b; Florezgonzalez et al. 1994; Naessig and Lanyon 2004; Whitehead and Glass 1985), and are probably killed by false killer whales and sharks. Calves remain protected near mothers or within a group, and lone calves have been known to be protected by presumably unrelated adults when confronted with attack (Ford and Reeves 2008).

4.2.5.5.3 Disease

Out of 13 marine mammal species examined in Alaska, domoic acid was detected in all species examined, with humpback whales showing 38% prevalence. Saxitoxin was detected in 10 of the 13 species, with the highest prevalence in humpback whales (50%) and bowhead whales (32%) (Lefebvre et al. 2016). The occurrence of the nematode *Crassicauda boopis* appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992).

4.2.5.5.4 Entrapment in Ice

Entrapments in ice have been documented in the spring ice pack in Newfoundland (Merdsoy et al. 1979), with up to 25 entrapped in the same event (Lien and Stenson 1986) and some mortalities reported. No humpback ice entrapments have been reported in the Chukchi Sea.

4.2.5.5.5 Subsistence Harvest

There are no reported takes of humpback whales from the western North Pacific or Mexico DPS by subsistence hunters in Alaska or Russia for the 2010-2014 period (Muto et al. 2017).

4.2.5.5.6 Unusual Mortality Event (UME)

In 2015, NMFS declared a UME for large whales in the western Gulf of Alaska that included 11 fin whales, 14 humpback whales, 1 gray whale, and 4 unidentified cetaceans. No specific cause for the increased mortality has been identified (Muto et al. 2017).

4.2.5.5.7 Fishery Interactions and Entanglements

Humpback whales are also killed, injured, and entangled during interactions with commercial fishing gear. In Alaska, interactions resulting in entanglements, mortality, or serious injury of humpback whales occurred in the following fisheries between 2010-2014: BSAI flatfish trawl, BSAI pollock trawl, Southeast Alaska salmon drift gillnet, Pacific cod jig, Bering Sea pot gear, Prince William Sound shrimp pot gear, and Gulf of Alaska Dungeness crab pot gear (Muto et al. 2017). Pot and trap gear are the most commonly documented source of mortality and serious injury to humpback whales off the U.S. West Coast outside of Alaska (Carretta et al. 2017).

A photography study of humpback whales in southeastern Alaska in 2003 and 2004 found at least 53% of individuals showed some kind of scarring from entanglement (Neilson et al. 2005).

4.2.5.5.8 Vessel Collisions

Vessel collisions with humpback whales remain a significant management concern, given the increasing abundance of humpback whales foraging in Alaska, as well as the growing presence of marine traffic in Alaska's coastal waters. Based on these factors, injury and mortality of humpback whales as a result of vessel strike may likely continue into the future (NMFS 2006). The potential for ship strikes also may increase as vessel traffic in northern latitudes increases with changes in sea-ice coverage (Muto et al. 2017).

Neilson et al. (2012) reviewed 108 whale-vessel collisions in Alaska from 1978-2011 and found that 86% involved humpback whales. Collision hotspots occurred in southeast Alaska in popular whale watching locations.

4.2.5.5.9 Other Stressors

Elevated levels of sound from anthropogenic sources (e.g., shipping, military sonar) are a potential concern for humpback whales in the North Pacific (Muto et al. 2017). A humpback was reported was reported entangled in a research wave rider buoy off the U.S. West Coast (Carretta et al. 2017). Other potential impacts include possible changes in prey distribution with climate change, entanglement in or ingestion of marine debris, impacts from oil and gas activities, and disturbance from whale watching activities (Muto et al. 2017).

4.2.6 Sperm whale (*Physeter macrocephalus*)

Figure 10. Global distribution of sperm whale (IUCN 2017).

4.2.6.1 Population Structure and Conservation Status

4.2.6.1.1 Population structure

The sperm whale is one of the most widely distributed marine mammals (Muto et al. 2017)(Figure 10). Currently, the population structure of sperm whales has not been adequately defined (NMFS 2010c). For management purposes under the MMPA, three stocks of sperm whale are currently recognized in U.S. waters of the Pacific Ocean: (1) Alaska (also termed North Pacific stock), (2) California/Washington/Oregon, and (3) Hawaii (Muto et al. 2017). The North Pacific stock is the only stock occurring in Alaska waters (Muto et al. 2017).

4.2.6.1.2 ESA status

NMFS listed the sperm whale as endangered in 1970 (35 FR 18319) under the ESCA following widespread significant depletions due to commercial whaling. Congress replaced the ESCA with the ESA in 1973, and sperm whales continued to be listed throughout their range as endangered. A recovery plan was prepared in 2010 (NMFS 2010c). Critical habitat has not been designated for this species.

4.2.6.1.3 Population estimate

Whitehead (2002) estimated the global abundance of sperm whale at 1,110,000 animals prior to commercial whaling. Rice (1989) estimated the North Pacific stock at 1,260,000 animals prior to exploitation (which is larger than Whitehead's estimate for the global population), and estimated that by the 1970s, the North Pacific stock had been reduced to 930,000 whales. Although the number of sperm whales occurring in Alaska waters is unknown, 102,112 sperm whales are estimated to occur in the western North Pacific region (Kato and Miyashita 1998). There is no current reliable estimate of the global abundance of sperm whale, or of the North Pacific stock in Alaska (Muto et al. 2017). Therefore, a population trend for sperm whales in the North Pacific stock is also not available (Muto et al. 2017).

4.2.6.2 Distribution

Sperm whales are the largest of the Odontocetes (toothed whales), inhabit all oceans worldwide, and can be observed along the pack ice edge in both hemispheres. They are most commonly found in deep ocean waters (typically deeper than 900 feet) between latitudes 60º N and 60º S. In the North Pacific the northernmost boundary for sperm whales extends from Cape Navarin, Russia (latitude 62º N) to the Pribilof Islands, Alaska (Allen and Angliss 2014; Omura 1955).

In the proposed action area sperm whales commonly occur in the Gulf of Alaska, Bering Sea, around the Aleutian Islands, and some parts of Southeast Alaska during the summer months (Muto et al. 2017). Sperm whales occur year around in the Gulf of Alaska, but appear to be more common during the summer months than winter months (Mellinger et al. 2004a). Sperm whales are thought to migrate to higher latitude foraging grounds in the summer and lower latitudes in the winter (Muto et al. 2017).

4.2.6.3 Natural History

Sperm whales feed primarily on medium-sized to large-sized squids, and also eat other prey items including cephalopods (such as octopi) and large demersal mesopelagic sharks, skates, and fishes (Allen and Angliss 2014; Rice 1989).

4.2.6.3.1 Vocalizations and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Sperm whales produce broad-band clicks in the frequency range of 100 Hz to 20 kHz that can be extremely loud for a biological source (peak sound source levels of 200-236 decibels re 1μPa), although lower average source level energy has been suggested at around 171 decibels re 1 μPa (Møhl et al. 2003; Weilgart and Whitehead 1993). Most of the energy in sperm whale clicks is concentrated at around 2-4 kHz and 10-16 kHz (Weilgart and Whitehead 1993). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Cranford et al. 1996).

Our understanding of sperm whale hearing stems largely from the sounds they produce. In addition, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echo-sounders and submarine sonar (Watkins et al. 1985). Because they spend large amounts of time at depth and use low-frequency sound, sperm whales are likely to be susceptible to low frequency noise in the ocean. Sperm whales are in the mid-frequency (MF) cetaceans functional hearing group (Southall et al. 2007).

4.2.6.4 Stressors/Threats

4.2.6.4.1 Fishery interactions

Sperm whale depredation events (whales removing or damaging fish caught on fishing gear) in Alaskan longline fisheries have been documented since the mid-1980s, and appear to have increased in frequency since the mid-1990s when the halibut and sablefish longline fisheries extended their seasons (Peterson and Hanselman 2017). Sperm whale depredation generally occurs in the central and eastern Gulf of Alaska, and rare occurrences have been documented in the western Aleutian Islands. Depredation by sperm whales in Alaskan waters is presumed to be primarily by solitary mature males from the North Pacific stock. There may be some disadvantages for depredating whales, such as increased risk of vessel strikes or entanglement in fishing gear. Research is ongoing to modify fishing practices to reduce depredation by sperm whales.

Between 2010 and 2014, there were 4 observed serious injuries of sperm whales in the Gulf of Alaska sablefish longline fishery. Thus, the mean annual estimated level of serious injury and mortality of the North Pacific stock of sperm whale stock from fisheries for 2010-2014 is 2.2 (Muto et al. 2017). In 2012, one suspected human-related sperm whale mortality was reported to NMFS, potentially due to a fishery interaction (Muto et al. 2017).

4.2.6.4.2 Other stressors

Although the main direct threat to sperm whales was addressed by the IWC moratorium on commercial whaling, several potential threats remain. Among the current potential threats are collisions with vessels, reduced prey abundance due to climate change, the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates, contaminants and pollutants, and, possibly, the effects of increasing anthropogenic ocean noise (NMFS 2010c). Sperm whales have never been reported to be taken by subsistence hunters (Muto et al. 2017).

4.2.7 Bowhead whale (*Balaena mysticetus*)

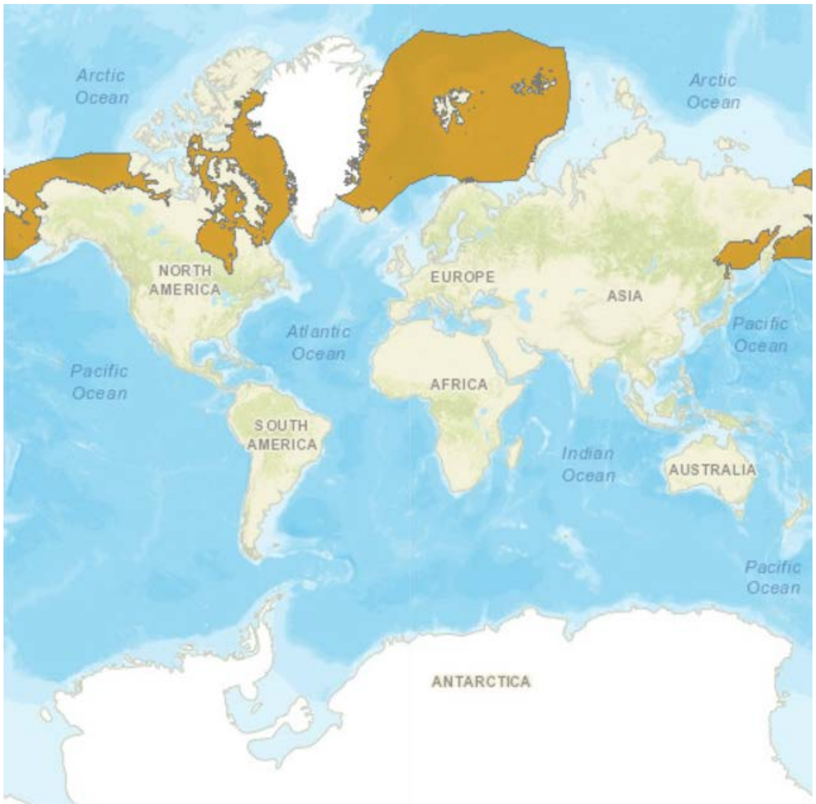

Figure 11. Global distribution of bowhead whale (IUCN 2017).

4.2.7.1 Population Structure and Conservation Status

4.2.7.1.1 Population structure

The International Whaling Commission (IWC) recognizes four stocks of bowhead whales for management purposes (Muto et al. 2017). The Western Arctic stock of bowhead whale is the only stock to inhabit U.S. waters (Muto et al. 2017). This stock migrates through the waters of northern and western Alaska between the Beaufort, Chukchi, and Bering seas.

4.2.7.1.2 ESA status

Historically, bowhead whales were severely depleted by commercial harvesting, which ultimately led to the listing of bowhead whales as an endangered species under the ECSA in 1970 (35 FR 18319). Congress replaced the ESCA with the ESA in 1973, and bowhead whales continued to be listed throughout their range as endangered under the ESA. A recovery plan has not been prepared for the bowhead whale. Critical habitat has not been designated.

4.2.7.1.3 Population estimate

The worldwide population of bowhead whales prior to commercial whaling is estimated to have been 50,000 with 9,190-23,000 whales in the Western Arctic stock (Brandon and Wade 2006;

Woodby and Botkin 1993). Western Arctic stock numbers dropped below 3,000 by the end of commercial whaling (Woodby and Botkin 1993).

Bowhead whale populations have increased significantly since the prohibitions on commercial whaling. From 1978-2001, the Western Arctic stock of bowhead whales increased at a rate of 3.4% annually, during which time abundance doubled from approximately 5,000 to approximately 10,000 whales (George et al. 2004). The most recent population estimate for the Western Arctic bowhead stock is 16,892 with a continued 3.7% annual rate of increase (Givens et al. 2013).

4.2.7.2 Distribution

Bowhead whales have a circumpolar distribution in high latitudes in the Northern Hemisphere, and range from 54º to 85º N latitude. They live in pack ice for most of the year, typically wintering at the southern limit of the pack ice, or in polynyas (large, semi-stable open areas of water within the ice), and move north as the sea ice breaks up and recedes during the spring. In the action area, bowhead whales are distributed in the seasonally ice-covered waters of the Arctic and subarctic, generally occurring north of 60°N and south of 75°N (Braham 1984a; Rugh et al. 2003).

Western Arctic bowheads are widely distributed in the northern Bering Sea during the winter (November-April), generally associated with the marginal ice front. Most of these whales migrate north and east from April-May traveling through the Chukchi Sea into the Beaufort Sea (Figure 12). Bowheads range through the Beaufort Sea during most of the summer (June to September) independent of ice cover. From early September to mid-October, the bowheads move west out of the Beaufort Sea and into the Chukchi Sea, returning to the Bering Sea through the Bering Strait by late-October and December (Figure 12) (Allen and Angliss 2014; Rugh et al. 2003). Some bowhead whales are found in the Chukchi and Bering Seas during the summer months, and are thought to be part of the expanding Western Arctic stock (Rugh et al. 2003).

Bowhead whales are closely associated with sea ice much of the year (Allen and Angliss 2014; Moore and Reeves 1993). The bowhead spring migration from the Bering Sea north to the Chukchi Sea follows polynyas in the sea ice along the coast of Alaska, generally in the zone between the shorefast ice and mobile pack ice. During the summer, most of the Western Arctic bowhead whales are in the southern Beaufort Sea, an area exposed to oil and gas development activity (Allen and Angliss 2014). During the fall migration south into the Bering Sea, bowheads appear to select shallow-shelf waters in low to moderate sea ice conditions, and slope waters in heavy ice conditions (Moore 2000a). In the Bering Sea wintering grounds bowheads often use areas with 100% sea ice cover, even when polynyas are available (Allen and Angliss 2014).

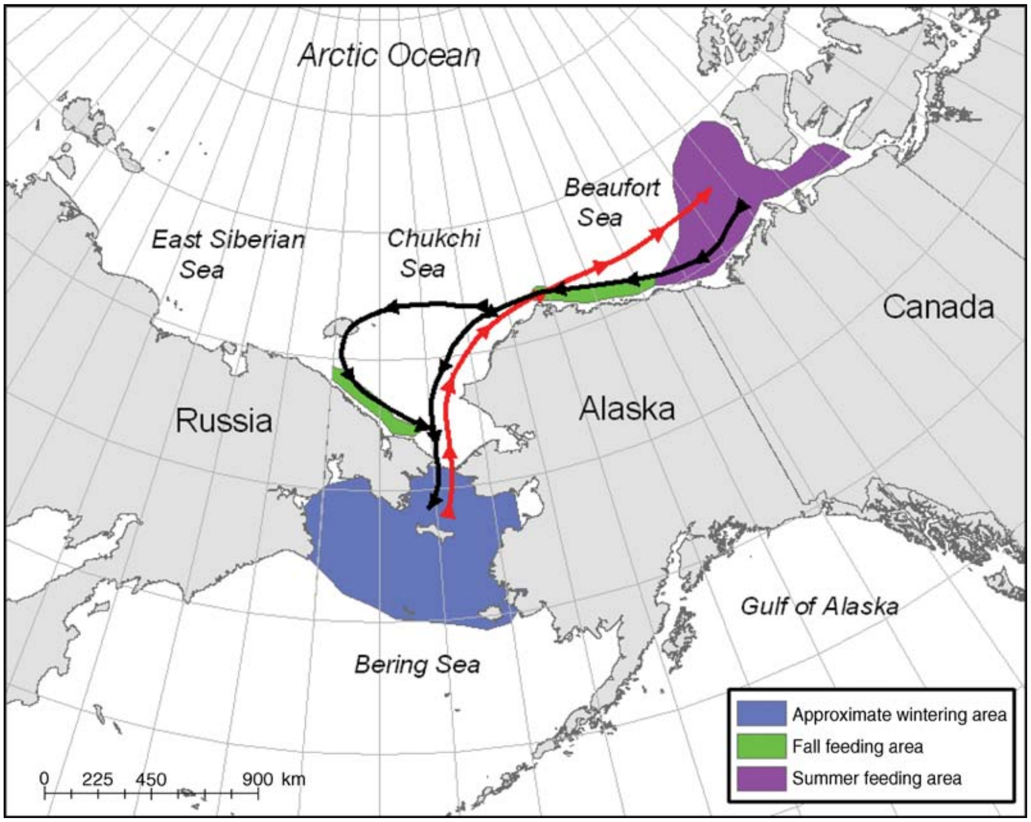

Figure 12. Migration route, feeding areas, and wintering areas for Western Arctic bowhead whales (Moore and Laidre 2006).

4.2.7.3 Natural History

Bowheads are filter feeders, filtering prey from the water through baleen fibers in their mouths (Lowry 1993). Food items found in the stomachs of harvested bowheads include euphausiids, copepods, mysids, amphipods, other invertebrates, and fishes (Lowry 1993). Euphausiids and copepods are thought to be their primary prey. It is likely there is considerable inter-annual variability in the locations where feeding occurs during the summer and fall in the Alaska Beaufort Sea, in the length of time individuals spend feeding, and in the number of individuals feeding in various areas in the Beaufort Sea.

Bowhead whales usually travel alone or in groups of three to four individuals, but have been observed in groups of approximately 200 individuals (Clarke et al. 2011a). Bowhead whales are well-adapted to navigate and survive in sea ice. Bowheads can move through areas with 100% sea ice coverage using their robust skulls to fracture ice up to 18 centimeters thick in order to breathe (Citta et al. 2012; George et al. 1989). Bowhead whales are thought to use the reverberations of their calls off the undersides of ice floes to help them assess ice thickness and navigate (George et al. 1989). Bowheads have extensive vocal capabilities and may use calls to maintain the social cohesion of groups, attract mates, dominate rivals, or locate food (Würsig and Clark 1993).

4.2.7.4 Vocalizations and hearing

Bowhead whales are in the low frequency (LF) cetacean functional hearing group (Southall et al. 2007). There is no direct information about the hearing abilities of baleen whales like bowheads, but inferring from their vocalizations, bowhead whales should be most sensitive to frequencies between 20 Hz-5 kHz, with maximum sensitivity between 100-500 Hz (Erbe 2002). Bowhead whale songs have a bandwidth of 20-5000 Hz with the dominant frequency at approximately 500 Hz, and last from 1 minute to hours. Pulsed vocalizations range between 25 and 3500 Hz and last 0.3 to 7.2 seconds (Erbe 2002; Würsig and Clark 1993).

Stressors/Threats

4.2.7.4.1 Fisheries interactions

Western Arctic bowhead whales are known to interact with fishing gear, which can result in mortality and serious injury. There are no observer program records of bowhead whale mortalities incidental to U.S. commercial fisheries; however, there have been bowhead interactions with crab pot gear and fishing nets. The minimum average entanglement rate of bowhead whales in U.S. commercial fisheries from 2010-2014 is 0.2 whales per year (Muto et al. 2017).

4.2.7.4.2 Subsistence harvest

Bowhead whales have been hunted and harvested for over 2,000 years for subsistence purposes (Stoker and Krupnik 1993), and subsistence takes have been regulated under a quota system by the International Whaling Commission since 1977 (Allen and Angliss 2014). Alaska native subsistence hunters (primarily from 11 northern Alaska communities) take approximately 0.1-0.5% of the population per year (Allen and Angliss 2014; Suydam et al. 2011). The IWC authorizes between 14 and 72 kills per year. The average annual subsistence harvest by Natives of Alaska, Russia, and Canada from 2010-2014 was 44 bowhead whales (Muto et al. 2017).

4.2.7.4.3 Predation

Transient killer whales are the only known non-human predators of bowhead whales. One study showed that 4.14% to 7.9% of subsistence harvested bowheads had scars indicating they had survived killer whale attacks (George et al. 1994).

4.2.7.4.4 Other stressors

Increasing oil and gas development in the Arctic has led to increased noise and disturbance for bowhead whales, increased risk of effects from pollution (including oil spills), and increased risk of ship strike from marine vessel activity. Evidence suggests that bowhead whales are sensitive to noise from offshore drilling platforms and seismic survey operations (Muto et al. 2017).

4.2.7.4.5 Climate change

Climate change is resulting in warming of northern latitudes at about twice the rate of more temperate latitudes. Currently, there are insufficient data to make reliable projections of the effects of Arctic climate change on bowhead whales (Muto et al. 2017), and increased ship traffic through the Arctic may expose bowhead whales to an increased risk of ship strikes, pollution, or oil spills.

However, conceptual models suggested that overall reductions in sea ice cover should increase the Western Arctic stock of bowhead whale prey availability (Moore and Laidre 2006). This theory may be substantiated by the steady increase in the Western Arctic bowhead population during the nearly 20 years of sea ice reductions (Walsh 2008). Bowhead whales are dependent on sea-ice organisms for feeding and polynyas for breathing, so the early melting of sea ice may lead to an increasing mismatch in the timing of these sea-ice organisms and secondary production (Loeng et al. 2005). George et al. (2006), showed that harvested bowheads had better body condition during years of light ice cover. Similarly, George et al. (2015) found an overall improvement in bowhead whale body condition and a positive correlation between body condition and summer sea ice loss over the last 2.5 decades in the Pacific Arctic. George et al. (2015) speculated that sea ice loss has positive effects on secondary trophic production within the Western Arctic bowhead whale's summer feeding region. Moore and Huntington (2008) anticipated that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change. Bowhead whales are dependent on sea-ice organisms for feeding and polynyas for breathing, so the early melting of sea ice may lead to an increasing mismatch in the timing of these sea-ice organisms and secondary production (Loeng et al. 2005). However, George et al. (2006) showed that landed bowheads had better body condition during years of light ice cover. Shelden et al. (2003) noted that there is a high probability that bowhead abundance will increase under a warming global climate.

4.2.8 North Pacific right whale (*Eubalaena japonica*)

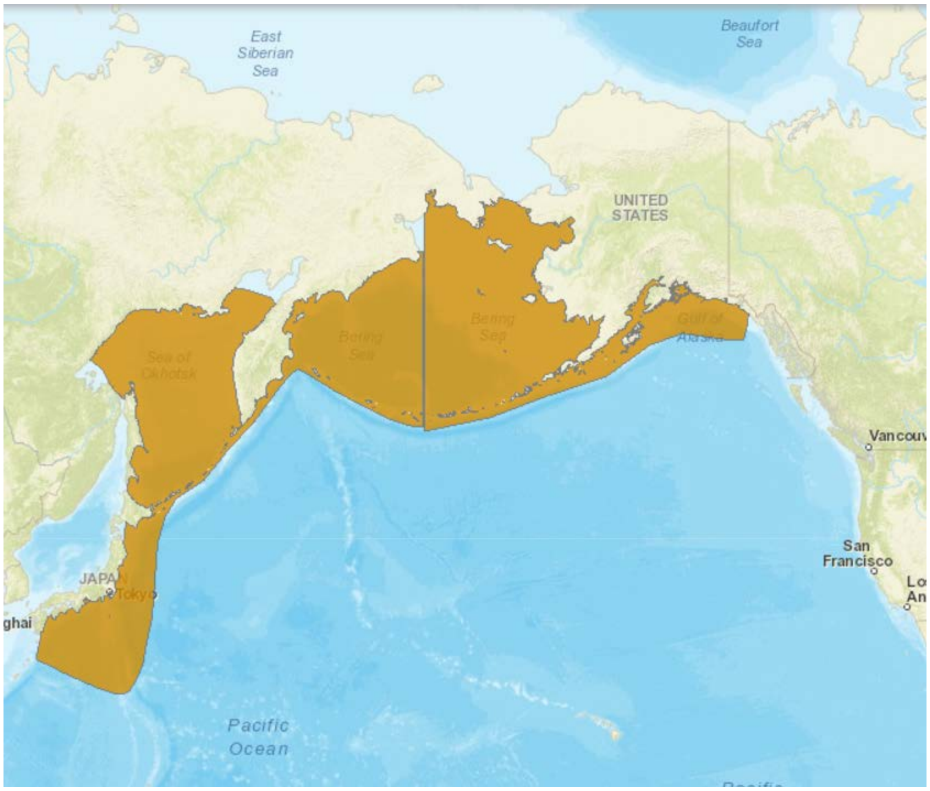

Figure 13. Distribution of North Pacific right whale (IUCN 2017).

4.2.8.1 Population Structure and Conservation Status

4.2.8.1.1 Population structure and ESA status

The northern right whale (*Eubalaena glacialis*) was listed as endangered under the ESCA on December 2, 1970 (35 FR 18319). Congress replaced the ESCA with the ESA in 1973, and northern right whales continued to be listed throughout their range as endangered under the ESA. In 2008, NMFS divided the northern right whale into two separate endangered species based on unequivocal genetic differences: the North Pacific right whale (*E. japonica*) and the North Atlantic right whale (*E. glacialis*) (73 FR 12024; March 6, 2008). Critical habitat for the northern right whale was designated in the North Pacific Ocean on July 6, 2006 (71 FR 38277), and critical habitat for the North Pacific right whale was re-designated on April 8, 2008 (73 FR 19000). A recovery plan was prepared in 2013 (NMFS 2013e).

The North Pacific right whale is comprised of two populations, the eastern and the western. The eastern population of North Pacific right whale occurs in the Bering Sea and Gulf of Alaska, but may range as far south as Baja California, Mexico in the eastern Pacific, and Hawaii in the central Pacific (Allen and Angliss 2014). This population was severely depleted by legal and illegal commercial whaling up until 1999 (Brownell et al. 2001; Wade et al. 2011a).

4.2.8.1.2 Population estimate

The eastern North Pacific right whale is arguably the most endangered stock of large whale in the world with approximately 31 individuals (Muto et al. 2017). The western population is also small and at risk of extinction; however, no reliable published estimate of abundance exists. Survey data suggest it is much larger than the eastern population, numbering several hundred or more animals (Brownell et al. 2001).

No estimate of trend in abundance is currently available (Muto et al. 2017).

4.2.8.2 Critical Habitat

In 2006, NMFS designed critical habitat for the "northern right whale" including the North Pacific right whale (71 FR 38277), which was not officially split from the North Atlantic individuals until 2008. Two areas in Alaska were included in the designation, one in the Bering Sea and one in the Gulf of Alaska (Figure 14), comprising a total of approximately 95,200 square kilometers (36,750 square miles) of marine habitat. From 1973 (when the species was listed under the ESA) to 2006 (when critical habitat was designated), 182 of 184 sightings of the North Pacific right whale north of the Aleutians occurred within the area in the Bering Sea designated as critical habitat, and 5 of 14 sightings in the Gulf of Alaska occurred within the Gulf of Alaska critical habitat (Figure 14).

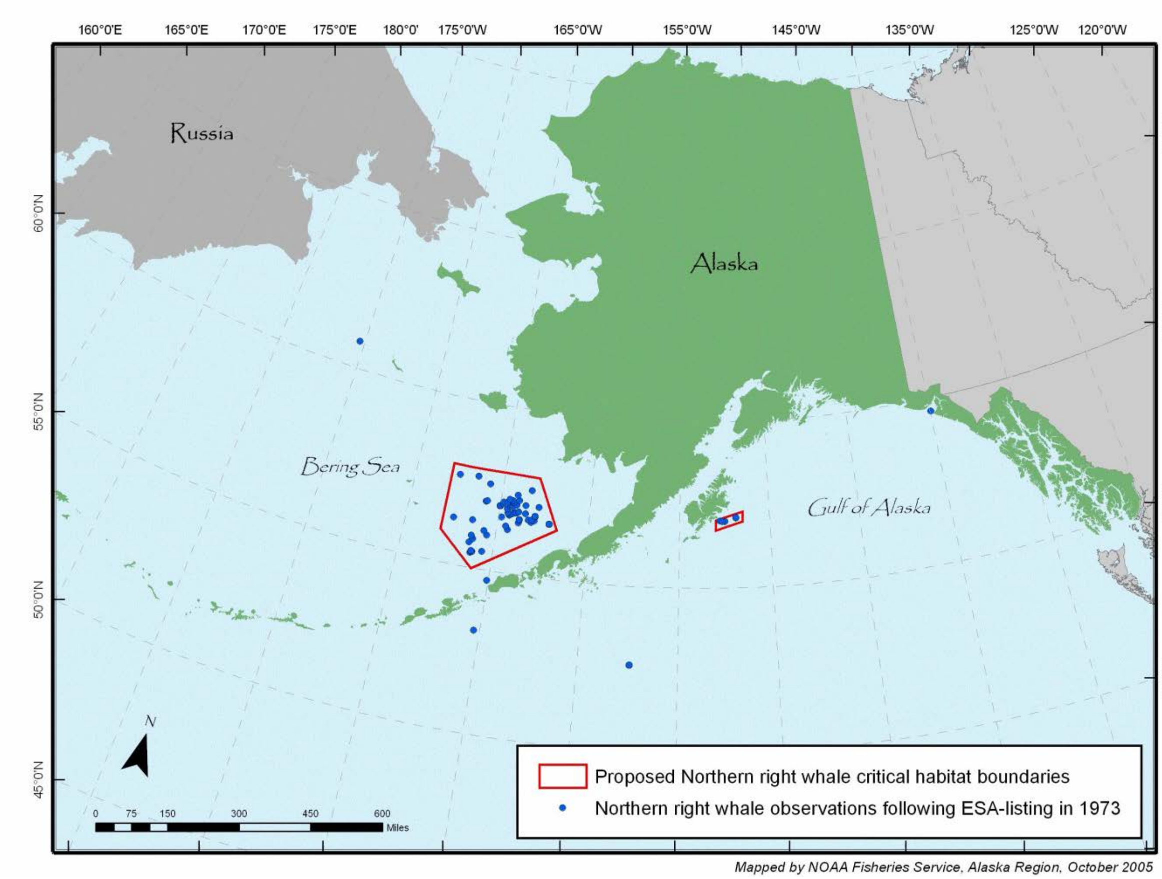

Figure 14. Map of Alaska showing the critical habitat designated for the North Pacific right whale, including recorded sightings of the species from 1973-2005.

In 2008, NMFS designated these same two sites in the Bering Sea and Gulf of Alaska as critical habitat for the North Pacific right whale soon after it was listed as endangered as a separate species from the North Atlantic right whale (73 FR 19000). The primary constituent elements protected by the 2008 critical habitat designation are species of large zooplankton in areas where right whales are known or believed to feed. In particular, this includes three species of copepods (*Calanus marshallae*, *Neocalanus cristatus*, and *N. plumchrus*) and one species of euphausiid (*Thysanoessa raschii*), whose large size, high lipid content, and occurrence in the region makes it the preferred prey for right whales (73 FR 19000, 19003; April 8, 2008). The two areas designated as critical habitat are characterized by certain physical and biological features which include nutrients, physical oceanographic processes, the above listed species of zooplankton, and long photoperiod due to the high latitude. These feeding areas support a significant assemblage of the remaining North Pacific right whales, and are critical in terms of their conservation value to the species.

4.2.8.3 Distribution

Whaling data indicate that North Pacific right whales once ranged across the entire North Pacific north of 35˚N and occasionally as far south as 20˚N (Scarff 1986; Scarff 2001). Prior to near extirpation due to commercial whaling, right whale concentrations were found in the Gulf of

Alaska, eastern Aleutian Islands, south-central Bering Sea, Sea of Okhotsk, and Sea of Japan (Braham and Rice 1984). Since 1962, most sightings of North Pacific right whales have been in the Bering Sea and adjacent areas of the Aleutian Islands, with additional sightings as far south as central Baja California, as far east as Yakutat, Alaska, and Vancouver Island in the eastern North Pacific, as far south as Hawaii in the central North Pacific, and as far north as the subarctic waters of the Bering Sea and Sea of Okhotsk (Muto et al. 2017). Most recent North Pacific right whale sightings have been in the southeastern Bering Sea, with a few in the Gulf of Alaska, near Kodiak (Shelden et al. 2005; Wade et al. 2011a; Wade et al. 2011b).

4.2.8.3.1 Winter distribution

It was thought this population migrated from high-latitude feeding grounds in summer to more temperate waters during the winter, possibly well offshore (Clapham et al. 2004; Scarff 1986). However, passive acoustic monitoring from 2011 to 2014 suggests that some North Pacific right whales may occur in the northern Bering Sea during winter months (Muto et al. 2017). An individual was visually identified north of St. Lawrence Island (northern Bering Sea) in November 2012 (Muto et al. 2017).

4.2.8.3.2 Summer distribution

In August 2017, two right whales were detected in Bristol Bay, about 55 miles east of their designated critical habitat.[10] Aerial and vessel surveys for right whales have occurred in a portion of the southeastern Bering Sea where right whales have been observed most summers since 1996 (Rone et al. 2012). Acoustic recorders in the southeastern Bering Sea have detected North Pacific right whales from May through January, with peak call detections in September and a sharp drop-off in detections by mid-November (Mellinger et al. 2004b; Munger et al. 2008; Stafford and Mellinger 2009; Stafford et al. 2010). The probability of acoustically detecting right whales in the Bering Sea is strongly influenced by the abundance of the copepod *Calanus marshallae*, a primary prey species for right whales on the Bering Sea shelf (Baumgartner et al. 2013).

Since 1980, eastern North Pacific right whales have been observed singly or in small groups, sometimes in association with dense zooplankton layers, south of Kodiak, in on-shelf and mid-slope waters in the Gulf of Alaska, near Unimak Pass in the Aleutian Islands, and on the mid-shelf of the Bering Sea, suggesting that this is important habitat for this population (Shelden et al. 2005; Wade et al. 2011a; Zerbini et al. 2010).

4.2.8.4 Natural History

Right whales are large, slow moving whales. They feed by continuously filtering prey through their baleen while swimming mouth agape through patches of zooplankton. Several species of

[10] NMFS, Marine Mammal Laboratory, unpublished data, available at https://www.afsc.noaa.gov/Science_blog/North_Pacific_right_whale_2.htm, accessed Sept. 26, 2017.

large copepods and other zooplankton constitute the primary prey of the North Pacific right whale.

4.2.8.4.1 Reproduction and Migration

Little is currently known about the rate of reproduction for North Pacific right whales. There have been very few confirmed sightings of calves in the North Pacific this century. Other species of right whales elsewhere in the world are known to calve every three to four years on average, although an increase in the inter-birth interval to more than five years has been reported for the North Atlantic right whale (Kraus et al. 2001).

Calving grounds for North Pacific right whales have not been located (Scarff 1986; Zerbini et al. 2010), and migratory patterns are relatively unknown.

4.2.8.4.2 Vocalizations and hearing

While no information is available on the North Pacific right whale hearing range, it is anticipated that they are low-frequency specialists similar to other baleen whales. Thickness and width measurements of the basilar membrane have been conducted on North Atlantic right whale and suggest an estimated hearing range of 10 Hz-22 kHz based on established marine mammal models (Parks et al. 2007). Low-frequency anthropogenic noise such as ship traffic can mask the hearing capabilities of whales, potentially affecting critical life-history events (NRC 2003), and can result in increased stress levels in right whales (Rolland et al. 2012).

4.2.8.5 Stressors/Threats

4.2.8.5.1 Fisheries interactions

There are no records of fisheries mortalities of eastern North Pacific right whales, however, gillnets were implicated in the death of a right whale off the Kamchatka Peninsula in Russia in 1989 (Muto et al. 2017). Multiple live North Pacific right whales have also been observed with scarring indicative of fisheries interactions (Bownell et al 2001, Burdin et al. 2004). And there have been two more mortalities reported (but not in the eastern population):

1. In March 2011 a young right whale was killed when it was entangled in a net off Oita Prefecture on Kyūshū Island in Japan (Dr. Tadasu Yamada pers. comm. Dee Allen, Marine Mammal Commission).
2. In October 2016, a right whale entangled in fishing gear was reported to have died while being disentangled in Volcano Bay, Hokkaido, Japan (Dr. Tadasu Yamada pers. comm. to the Marine Mammal Commission). According to the Hokkaido Stranding Network meat from this animal was also sold at a local market (http://kujira110.com/?p=2175).

Entanglement in fishing gear, including lobster pot and sink gillnet gear, is a significant source of mortality for the North Atlantic right whale stock (Hayes et al. 2017; Waring et al. 2004). Two potential entanglements of North Pacific right whales have been discovered (Muto et al. 2017). There is considerable fishing activity within portions of the critical habitat of this species, increasing the risk of entanglement (Muto et al. 2017). Any mortality or serious injury incidental to commercial fisheries would be considered significant (Muto et al. 2017).

4.2.8.5.2 Vessel traffic

Right whales are slow-moving animals and are susceptible to injury or mortality by ship strike. Vessel collisions are considered the primary source of human-caused mortality of right whales in the North Atlantic (Cole et al. 2005). However, due to their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strikes to North Pacific right whales at this time. There is concern regarding the effects of increased shipping through Arctic waters and Bering Sea with retreating sea ice, which may increase the potential risk to right whales from shipping (Muto et al. 2017). Additionally, there is a high volume of large vessels that transit Unimak Pass through the Aleutian Islands between the Gulf of Alaska and the Bering Sea that is expected to increase (Nuka Research and Planning Group 2015), thereby increasing the potential for ship strikes and the risk of oil spills that could affect North Pacific right whales and their critical habitat.

4.2.8.5.3 Subsistence harvest

Subsistence hunters in Alaska and Russia are not reported to take North Pacific right whales (Muto et al. 2017).

4.2.8.5.4 Predation

Although killer whales do attack other large whales in Alaska (George et al. 1994), there is no evidence that killer whales attack North Pacific right whales.

4.2.8.5.5 Climate change

Changes in oceanographic conditions that impact the availability of zooplankton (Stabeno et al. 2012), the primary prey of North Pacific right whales, has the potential to impact the health and fitness of this species. A number of factors, including a warming climate, are expected to significantly change the distribution and abundance of zooplankton within key feeding areas for the North Pacific right whale in the future (Mueter and Litzow 2008).

4.2.9 Bearded seal (*Erignathus barbatus nauticus*)

4.2.9.1 Population Structure, Distribution, and Conservation Status

There are two described subspecies of bearded seal: *E. b. barbatus,* which inhabits the Atlantic region (Laptev, Kara, and Barents seas; North Atlantic Ocean; and Hudson Bay), and *E. b. nauticus*, which inhabits the Pacific region (remaining portions of the Arctic Ocean and the Bering and Okhotsk seas) (Rice 1998). The geographic distributions of the subspecies are not separated by distinct gaps, and regions of overlap occur along the Russian and central Canadian coasts (Rice 1998). Two distinct population segments (DPSs) are recognized for the *E. b. nauticus* subspecies–the Okhotsk DPS in the Sea of Okhotsk, and the Beringia DPS, which occurs in the Bering, Chukchi, Beaufort, and East Siberian seas. Only the Beringia DPS of bearded seals is found in U.S. waters and in the action area (Figure 15)(Muto et al. 2017).

NMFS listed the Beringia DPS of bearded seals as threatened under the ESA on December 28, 2012 (77 FR 76740), primarily due to anticipated loss of sea ice through the end of the 21st century due to ongoing climate change (Muto et al. 2017). A recovery plan has not yet been prepared, and critical habitat has not yet been designated for this species.

A reliable population estimate is not available (Muto et al. 2017). In a core area of their range in the central and eastern Bering Sea, the Beringia DPS abundance was estimated to be 61,800 seals (Ver Hoef et al. 2013). Another study estimated the abundance for the entire range of the Beringia DPS at 155,150 seals (Cameron et al. 2010). A joint research effort between Russian and U.S. scientists conducted aerial abundance and distribution surveys over the entire Bering Sea and Sea of Okhotsk in 2012 and 2013. A preliminary abundance estimate from that effort is approximately 300,000 seals, an estimate that does not include bearded seals in the Chukchi and Beaufort Seas at the time of the surveys (Muto et al. 2017). A reliable estimate of the trend in abundance of the Beringia DPS of bearded seals is not available (Muto et al. 2017).

4.2.9.2 Natural History

Bearded seals closely associate with sea ice, particularly during the critical life history periods related to reproduction and molting, and can be found in a broad range of ice types. They generally prefer ice habitat that is in constant motion and produces natural openings and areas of open water such as leads, fractures, and polynyas, for breathing, hauling out on the ice, and access to water for foraging (Heptner et al. 1976a). Bearded seals tend to prefer areas with 70-90% sea ice coverage, and typically are more abundant 20-100 nautical miles from shore than within 20 nautical miles of shore (Bengtson et al. 2005). Many of the bearded seals that spend the winter in the Bering Sea migrate north through the Bering Strait from late-April through June, and spend the summer near the ice edge in the Chukchi Sea (Allen and Angliss 2014). Summer distribution is broad with seals rarely hauled up on land, and some seals that do not follow the ice north remain near the coasts of the Bering and Chukchi Seas (Allen and Angliss 2014; Heptner et al. 1976a). As the ice forms again in the fall and winter, most bearded seals move south with the advancing ice edge through Bering Strait and into the Bering Sea where they spend the winter (Burns and Frost 1979; Cameron et al. 2010; Cameron and Boveng 2009). This southward migration is less noticeable and predictable than the northward movements in late spring, early summer (Burns 1981; Burns and Frost 1979; Cameron et al. 2010).

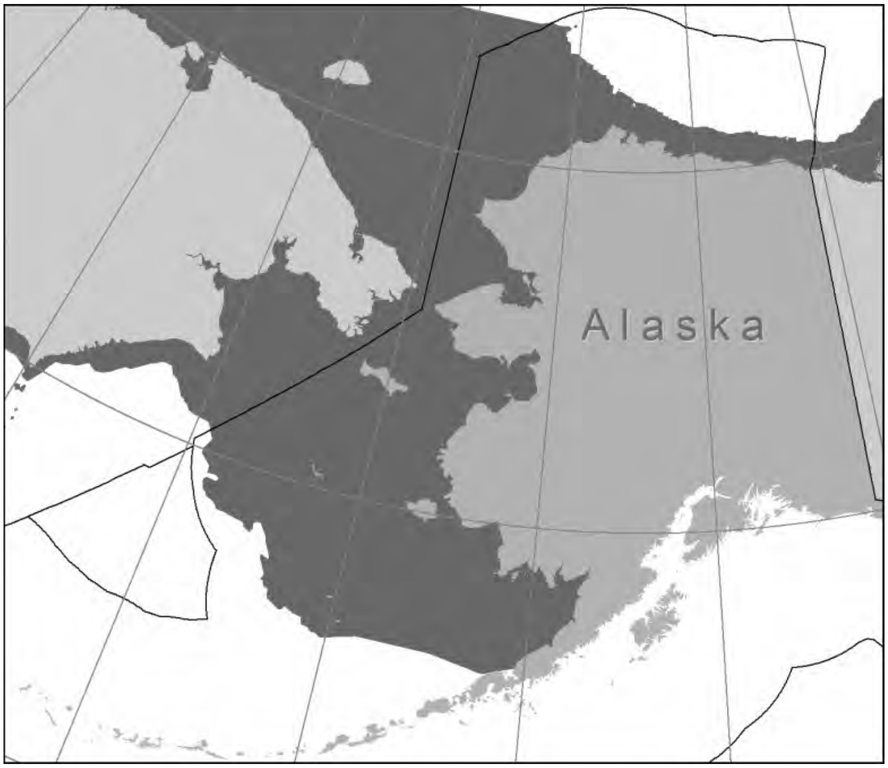

Figure 15. Approximate distribution of Beringia DPS bearded seals (shaded area) in Alaska. The combined summer and winter distributions are depicted (Muto et al. 2017).

The Bering and Chukchi Seas are the largest area of continuous habitat for bearded seals (Allen and Angliss 2014; Burns 1981). Bearded seals can reach the bottom everywhere along the relatively shallow Bering Sea shelf thereby foraging more efficiently (Burns 1967). The Bering and Chukchi Seas are generally covered by sea ice in late-winter and spring and are then mostly ice free in late-summer and fall, a process that drives a seasonal pattern in the movements and distribution of bearded seals in this area (Allen and Angliss 2014; Burns 1967).

Bearded seals are foraging generalists, but feed primarily on benthic organisms, which include invertebrates and demersal fishes (Cameron et al. 2010). They are able to switch their diet to pelagic schooling fishes when readily available. The bulk of their diet is bivalve mollusks, crustaceans such as crab and shrimp, and fishes such as sculpin, Arctic cod, saffron cod (*Eleginus gracilis*), and polar cod (*Arctogadus glacialis*) (Cameron et al. 2010). They primarily feed on or near the bottom, generally diving to depths of less than 100 meters (though dives of adults have been recorded up to 300 meters and young-of-the-year have been recorded diving down almost 500 meters) (Gjertz et al. 2000). Unlike walrus that root in the soft sediment for benthic organisms, bearded seals are believed to scan the surface of the seafloor with their highly sensitive whiskers, burrowing only in the pursuit of prey (Marshall et al. 2006; Marshall et al. 2008). Diet may vary with age, location, season, and possible changes in prey availability (Cameron et al. 2010).

Bearded seals are solitary throughout most of the year except for the breeding season. In the spring, adult males are suspected to spend a majority of their time in the water vocalizing and defending territories, though a few observations suggest they are not entirely aquatic and may haul out near females with or without pups (Burns 1967; Finley and Renaud 1980).

Pinnipeds have a well-developed vestibular apparatus that likely provides multiple sensory cues similar to those of most land mammals (Southall et al. 2007). Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, though they can hear underwater sounds at frequencies up to 60 kHz and make calls between 90 Hz and 16 kHz (Richardson et al. 1995a). A more recent review suggests that the auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall et al. 2007). Anthropogenic noise has the potential to mask biologically important sounds for bearded seals, resulting in increased energy expenditure and changes in behavior (Cameron et al. 2010). Noise exposure may affect the vestibular and neurosensory systems of bearded seals. In pinnipeds, there is direct coupling through the vestibule of the vestibular and auditory systems; therefore, it is possible that noise-induced effects may impact vestibular function as has been shown in land mammals and humans (Southall et al. 2007). Bearded seals are in the phocid pinniped (PW) functional hearing group (Southall et al. 2007).

4.2.9.3 Stressors/Threats

4.2.9.3.1 Fishery interactions

Between 2010 and 2014, there were incidental serious injuries and mortalities of bearded seals in the BSAI pollock trawl, BSAI flatfish trawl, and BSAI Pacific cod trawl fisheries. The estimated minimum mortality rate incidental to commercial fisheries is 1.4 (CV = 0.04) bearded seals per year, based exclusively on observer data (Muto et al. 2017).

4.2.9.3.2 Subsistence harvest

Bearded seals are an important subsistence species for Alaska Natives. Only 12 of the 64 coastal communities known to harvest bearded seals were surveyed from 2009 to 2013, so statewide harvest estimates are not available. Based on the harvest data from these 12 surveyed communities, a minimum estimate of the average annual bearded seal harvest Alaska-wide for 2009-2013 is 390 seals per year (Muto et al. 2017). Bearded seal harvests include harvests from villages and communities in the BSAIRA and in the CSBSRA.

4.2.9.3.3 Marine mammal research activities

Mortalities may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Between 2010-2014, no research related mortalities or injuries were reported for the Alaska population of bearded seals (Muto et al. 2017).

4.2.9.3.4 Northern Pinniped Unusual Mortality Event (UME)

Beginning in 2011, elevated numbers of sick or dead seals with skin lesions were discovered in the Arctic and Bering Strait regions, prompting NMFS to declare a UME. To date, no specific cause for the disease has been identified (Muto et al. 2017). Since 2014, few sick animals have been reported.[11]

4.2.9.3.5 Predation

Direct observations or data on predation of bearded seals are limited. Known predators include polar bears, killer whales, brown bears, and rarely, walruses (Cameron et al. 2010; Heptner et al. 1976a; Lowry and Fay 1984). The Greenland shark is also a suspected predator of bearded seals (Heptner et al. 1976a).

4.2.9.3.6 Climate change

The main concern about the conservation status of bearded seals stems from the likelihood that their sea-ice habitat has been modified by the warming climate and, more so, that the scientific projections are for continued and perhaps accelerated warming in the foreseeable future (Cameron et al. 2010). For bearded seals, the presence of sea ice is considered a requirement for whelping and nursing young. A second major concern, driven primarily by the production of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem (Muto et al. 2017).

4.2.9.3.7 Other stressors

Additional concerns include the potential effects from increased shipping (particularly in the Bering Strait), and oil and gas exploration activities (particularly in the outer continental shelf leasing areas), such as disturbance from vessel traffic, seismic exploration noise, or the potential for oil spills (Muto et al. 2017).

4.2.10 Ringed seal (*Phoca (=Pusa) hispida hispida*)

4.2.10.1 Population Structure, Distribution, and Conservation Status

Most taxonomists recognize 5 subspecies of ringed seals. The Arctic ringed seal subspecies (*Pusa hispida hispida*) occurs in the Arctic Ocean and Bering Sea and is the only stock that occurs in U.S. waters and within the proposed action area. Arctic ringed seals have a circumpolar distribution, occur in all seas of the Arctic Ocean, and range seasonally into adjacent seas, including the Bering Sea. Arctic ringed seals are year-round residents in the Chukchi and Beaufort Seas (Figure 16).

NMFS listed the Arctic ringed seal subspecies as threatened under the ESA on December 28, 2012 (77 FR 76706), primarily due to anticipated loss of sea ice through the end of the 21st

[11] NMFS Alaska Region, June 2016 UME update, Available at https://alaskafisheries.noaa.gov/sites/default/files/umefactsheet062016.pdf, accessed October 4, 2017.

century due to ongoing climate change (Kelly et al. 2010b). A recovery plan has not yet been prepared, and critical habitat has not yet been designated for this species.

The Arctic subspecies of ringed seals are thought to number over 1 million, while the Alaska stock is estimated to number at least 300,000 seals (Kelly et al. 2010b; Muto et al. 2017). A reliable estimate of the trend in abundance of the Alaska stock of ringed seals is not currently available (Muto et al. 2017).

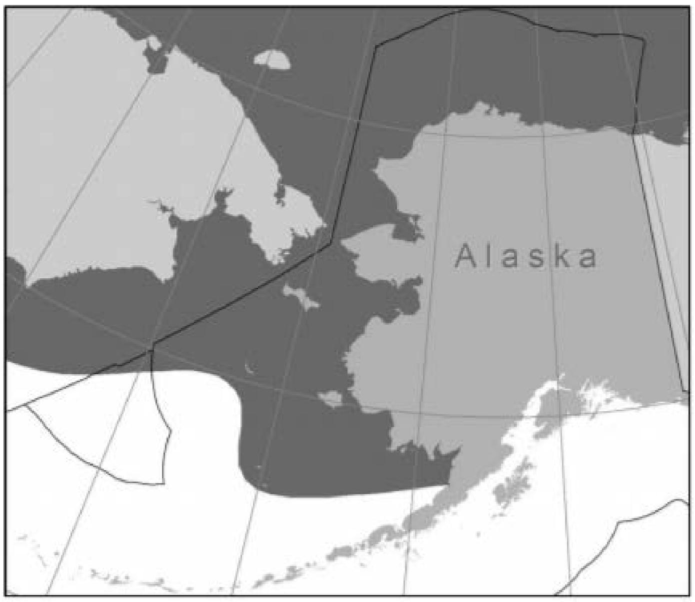

Figure 16. Approximate winter distribution of ringed seals (dark shaded area) (Muto et al. 2017).

4.2.10.2 Natural History

Arctic ringed seals remain in contact with sea ice most of the year and use it as a platform for pupping and nursing in late winter and early spring, molting from late spring to early summer, and resting throughout the year (Figure 17). They are well-adapted to occupying shorefast and pack ice and are rarely observed onshore (Kelly et al. 2010a). The seasonality of ice cover strongly influences ringed seal movements, foraging, reproductive behavior, and vulnerability to predation.

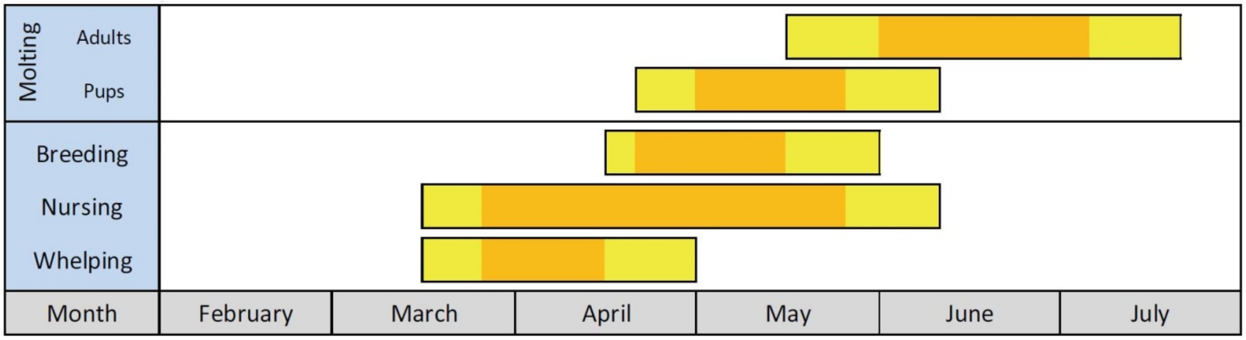

Figure 17. Approximate annual timing of reproduction and molting for Arctic ringed seals. Yellow bars indicate the normal range over which each event is reported to occur, and orange bars indicate the peak timing of each event (Kelly et al. 2010b).

Ringed seals eat a wide variety of prey in several trophic levels. They most commonly eat small fish (5-10 cm) and crustaceans (2-6 cm). Regional variation in diet is likely due to differences in prey availability and preference, oceanographic differences (e.g., water depth), and sea ice cover (Kelly et al. 2010b). Despite regional differences, gadid fishes tend to be the primary prey of ringed seals from late autumn to early spring, and Arctic cod (*Boreogadus saida*) is often reported to be the most common gadid in seal diets during ice covered months. Invertebrates appear to be an important diet component during open-water months, and large zooplankton are also a significant prey item seasonally (Kelly et al. 2010b).

Ringed seals vocalize underwater in association with territorial and mating behaviors. Underwater audiograms for phocids suggest that they have very little hearing sensitivity below 1 kHz, though they can hear underwater sounds at frequencies up to 60 kHz and make calls between 90 Hz and 16 kHz (Richardson et al. 1995a). A more recent review suggests that the auditory bandwidth for pinnipeds in water should be considered to be 75 Hz to 75 kHz (Southall et al. 2007). Anthropogenic noise has the potential to mask biologically important sounds and even cause injury to ringed seals (Kelly et al. 2010b). Noise exposure may affect the vestibular and neurosensory systems of ringed seals. In pinnipeds, there is direct coupling through the vestibule of the vestibular and auditory systems; therefore, it is possible that noise-induced effects may impact vestibular function as has been shown in land mammals and humans (Southall et al. 2007). Noise-induced effects on vestibular function may be even more pronounced in ringed seals than in land mammals considering a single vibrissa on a ringed seal contains ten times the number of nerve fibers typically found in one vibrissa of a land mammal (Hyvärinen 1989). Arctic subspecies of ringed seals are in the phocid pinniped (PW) functional hearing group (Southall et al. 2007).

4.2.10.3 Stressors/Threats

4.2.10.3.1 Fishery interactions

Between 2010 and 2014, there were incidental serious injuries and mortalities of ringed seals in the BSAI flatfish trawl, BSAI pollock trawl, BSAI Pacific cod trawl, and BSAI Pacific cod longline fisheries. Based on data from 2010 to 2014, there was an annual average rate of mortality and serious injury of 3.9 ringed seals incidental to commercial fishing operations (Muto et al. 2017).

4.2.10.3.2 Subsistence harvest

Ringed seals are an important subsistence species for Alaska Natives. Only 12 of the 64 coastal communities known to harvest bearded seals and ringed seals were surveyed from 2009 to 2013, so statewide harvest estimates are not available. Based on the harvest data from these 12 surveyed communities, minimum estimates of the average annual ringed seal harvest Alaska-wide for 2009-2013 is 1,050 seals (Muto et al. 2017). Ringed seal harvest estimates include harvests from villages and communities in the action area.

4.2.10.3.3 Northern Pinniped Unusual Mortality Event

Beginning in 2011, elevated numbers of sick or dead seals (primarily ringed seals) with skin lesions were discovered in the Arctic and Bering Strait regions prompting NMFS to declare a UME. To date, no specific cause for the disease has been identified (Muto et al. 2017). Since 2014, few sick animals have been reported.[11]

4.2.10.3.4 Marine mammal research activities

Mortalities may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Between 2010-2014, there was a mean annual mortality and serious injury rate of 0.2 ringed seals from the Alaska stock of the Arctic subspecies of ringed seals (Muto et al. 2017).

4.2.10.3.5 Predation

Ringed seal predators include polar bears (*Ursus maritimus*), brown bears (*Ursus arctos*), Arctic foxes (*Vulpes lagopus*), red foxes (*Vulpes vulpes*), gray wolves (*Canis lupus*), lynx (*Lynx lynx*), European mink (*Mustela lutreola*), walruses (*Odobenus rosmarus*), killer whales (*Orcinus orca*), Greenland sharks (*Somniosus microcephalus*), common ravens (*Corvus corax*), and glaucous gulls (*Larus hyperboreus*) (Burns and Eley 1976; Fay et al. 1990; Heptner et al. 1976b; Melnikov and Zagrebin 2005; Sipilä 2003). Polar bears prey heavily on ringed seals but with regional and temporal variation (Kelly et al. 2010b).

4.2.10.3.6 Climate change

The main concern about the status of ringed seals stems from the likelihood that their sea-ice and snow habitats have been modified by the warming climate and, more so, that the scientific consensus projections are for continued and perhaps accelerated warming in the foreseeable future that will continue to modify sea-ice and snow habitats for ringed seals (Kelly et al. 2010b).

Climate models consistently project overall diminishing ice and snow cover through the 21st century with regional variation in the timing and severity of those loses. Increasing atmospheric concentrations of greenhouse gases are driving climate warming and increasing acidification of the ringed seal's habitat. Changes in ocean temperature, acidification, and ice cover also threaten prey communities on which ringed seals depend (Muto et al. 2017). Laidre et al. (2008) concluded that on a worldwide basis ringed seals are likely to be highly sensitive to climate change based on an analysis of various life history features that could be affected by climate.

4.2.10.3.7 Other stressors

Additional concerns include the potential effects from increased shipping (particularly in the Bering Strait), and oil and gas exploration activities (particularly in the outer continental shelf leasing areas), such as disturbance from vessel traffic, seismic exploration noise, or the potential for oil spills (Muto et al. 2017).

4.2.11 Steller sea lion (*Eumetopias jubatus*)

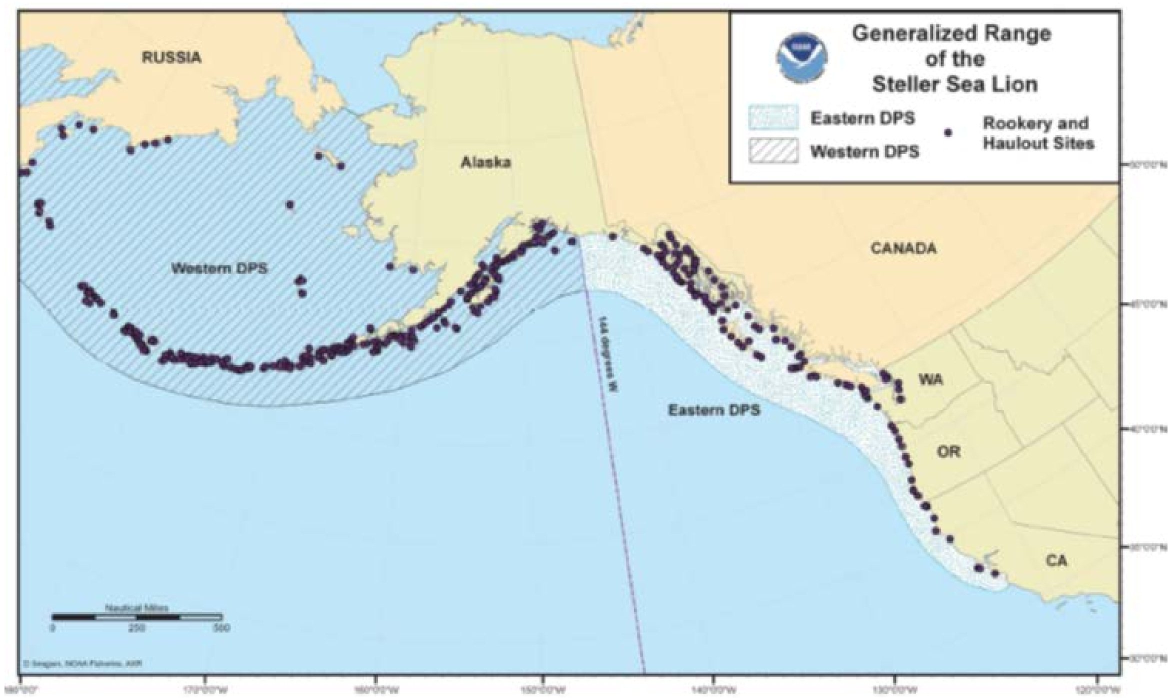

Figure 18. Ranges of the eastern and western DPSs of Steller sea lion.

4.2.11.1 Population Structure and Conservation Status

The Steller sea lion was listed as a threatened species under the ESA on November 26, 1990 (55 FR 49204). In 1997, NMFS reclassified Steller sea lions as two DPSs based on genetic studies and other information (62 FR 24345; May 5, 1997). At that time, the eastern DPS was listed as threatened, and the western DPS was listed as endangered. On November 4, 2013, the eastern DPS was removed from the endangered species list (78 FR 66140). Information on Steller sea lion biology, threats, and habitat (including critical habitat) is available online at: http://alaskafisheries.noaa.gov/protectedresources/stellers/default.htm and in the revised Steller

Sea Lion Recovery Plan (NMFS 2008), which can be accessed at: http://alaskafisheries.noaa.gov/protectedresources/stellers/recovery/sslrpfinalrev030408.pdf .

Numbers of Steller sea lions declined dramatically throughout much of the species' range, beginning in the mid- to late 1970s (Braham *et al.* 1980, Merrick et al. 1987, NMFS 1992, NMFS 1995). For two decades prior to the decline, the estimated total population was 250,000 to 300,000 animals (Kenyon and Rice 1961, Loughlin et al. 1984). The population estimate declined by 50-60 percent to about 116,000 animals by 1989 (NMFS 1992), and by an additional 15 percent by 1994, with the entire decline occurring in the range of the western DPS.

The 2016 Stock Assessment Report for the western DPS of Steller sea lions indicates a minimum population estimate of 50,983 individuals (Muto et al. 2017). Data collected through 2015 indicate an increase of about 2% per year in non-pup and pup counts of the western DPS between 2000 and 2015. This trend varies by region, with positive trends in the eastern portion of their range and negative trends further west in the Aleutian Islands (Muto et al. 2017).

4.2.11.2 Critical Habitat

NMFS designated Steller sea lion critical habitat on August 27, 1993 (58 FR 45269). Steller sea lion critical habitat in Western Alaska (west of 144° W. longitude) includes a 20 nautical mile buffer around all major haulouts and rookeries, as well as associated 3,000-feet terrestrial and air zones, and three large offshore foraging areas (Figure 19) (50 CFR 226.202(a)-(c)). Critical habitat in Southeast Alaska (east of 144° W. longitude) includes a terrestrial zone, an aquatic zone, and an air zone that extend 3,000 feet landward, seaward, and above, respectively, at each major rookery and haulout (Figure 20) (50 CFR 226.202(a)).

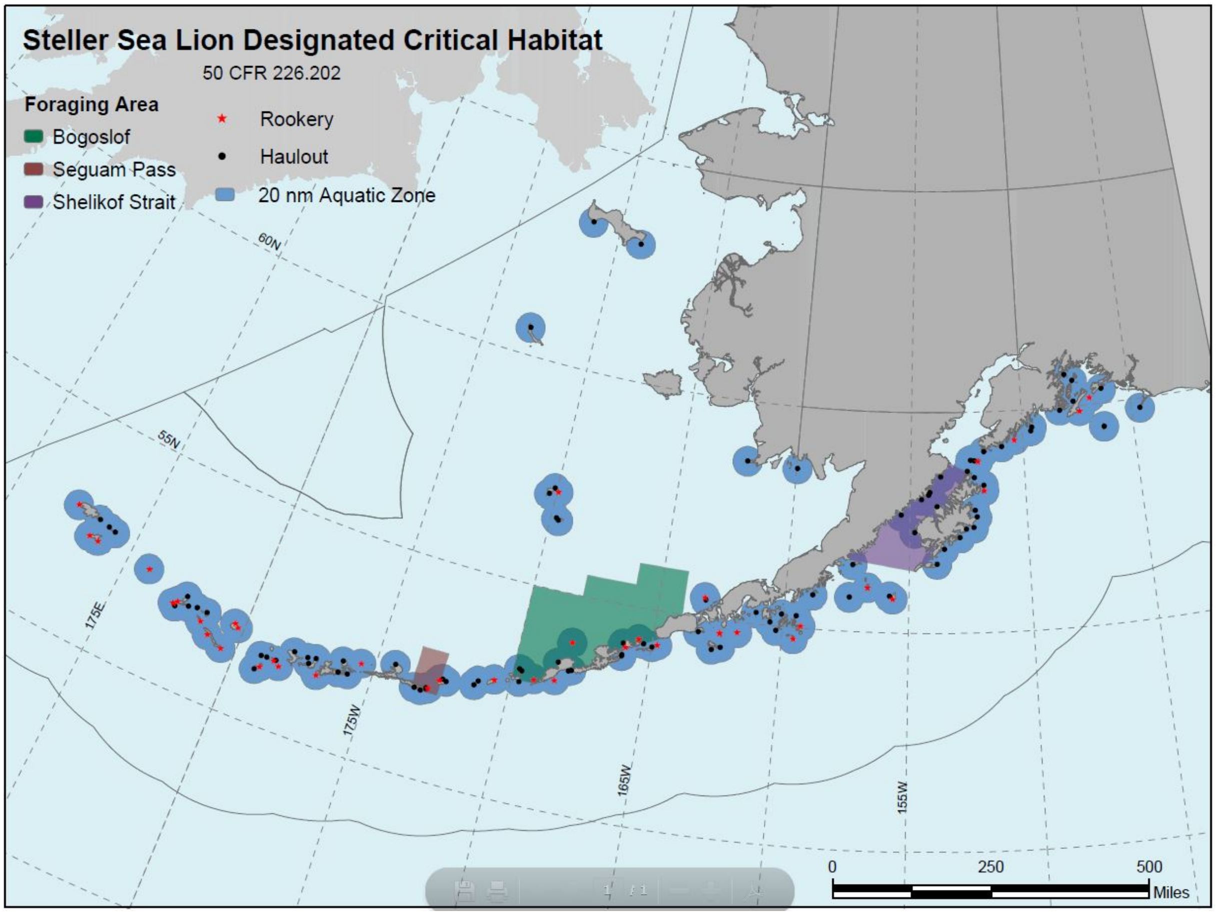

Figure 19. Designated Steller sea lion critical habitat in Western Alaska.

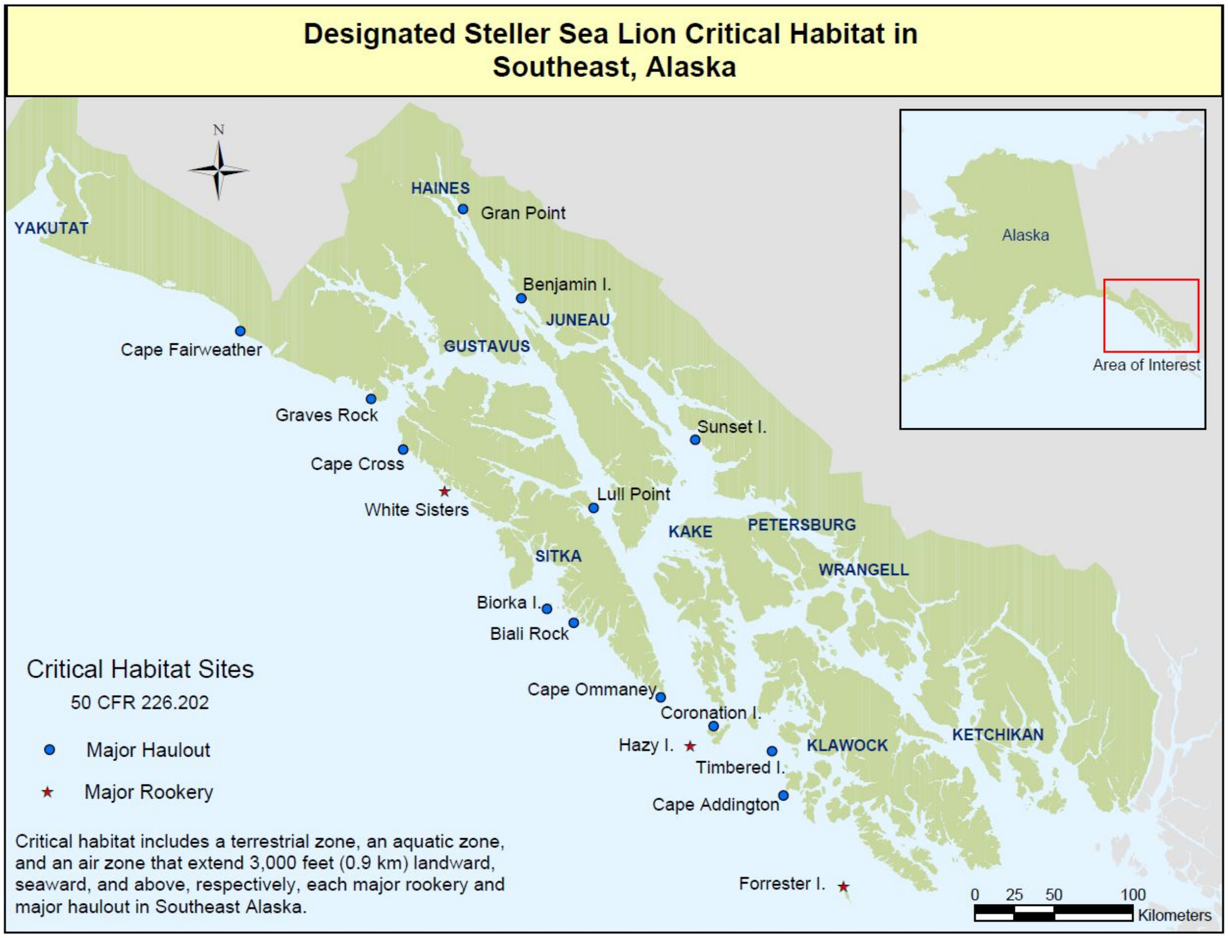

Figure 20. Designated Steller sea lion critical habitat in Southeast Alaska.

The areas designated as critical habitat for the Steller sea lion were determined using the best information available at the time, including information on land use patterns, the extent of foraging trips, and the availability of prey items. Particular attention was paid to life history traits and the areas where animals haul out to rest, pup, nurse their pups, mate, and molt.

4.2.11.3 Distribution

Steller sea lions range throughout the North Pacific Ocean from Japan, east to Alaska, and south to central California (Loughlin et al. 1984). They range north to the Bering Strait, with significant numbers at haul-outs on St. Lawrence Island in the spring and fall (Kenyon and Rice 1961; Sheffield and Jemison 2010). Breeding range extends along the northern edge of the North Pacific Ocean from the Kuril Islands, Japan, through the Aleutian Islands and Southeast Alaska, south to California (Loughlin et al. 1984).

4.2.11.4 Natural History

Steller sea lions belong to the family Otariidae, which includes fur seals (*Callorhinus ursinus*). Steller sea lions are the largest otariid and show marked sexual dimorphism with males 2-3 times larger than females. On average, adult males weigh 566 kg (1,248 lb), and adult females are much smaller, weighing on average 263 kg (580 lb; Fiscus 1961; Calkins and Pitcher 1982; Winship *et al*. 2001).

Land sites used by Steller sea lions are referred to as rookeries and haulouts. Rookeries are used by adult sea lions for pupping, nursing, and mating during the reproductive season (generally from late May to early July). Haulouts are used by all age classes of both genders but are generally not where sea lions reproduce. Sea lions move onshore and offshore for feeding excursions. At the end of the reproductive season, some females may move with their pups to other haulout sites, and males may migrate to distant foraging locations (Pitcher and Calkins 1981; Spalding 1964). Sea lions may make semi-permanent or permanent one-way movements from one site to another (Burkanov and Loughlin 2005; Chumbley et al. 1997). Round trip migrations of greater than 6,500 km by individual Steller sea lions have been documented (Jemison et al. 2013).

Most adult Steller sea lions occupy rookeries during the pupping and breeding season, which extends from late May to early July (Pitcher and Calkins 1981, Gisiner 1985), and exhibit high site fidelity (Sandegren 1970). During the breeding season some juveniles and non-breeding adults occur at or near the rookeries, but most are on haulouts (Rice 1998; Ban 2005; Call and Loughlin 2005).

The foraging strategy of Steller sea lions is strongly influenced by seasonality of sea lion reproductive activities on rookeries and the ephemeral nature of many prey species. Steller sea lions are generalist predators that eat a variety of fishes and cephalopods (Calkins and Goodwin 1988; NMFS 2008; Pitcher 1981), and occasionally other marine mammals and birds (NMFS 2008; Pitcher and Fay 1982).

The ability to detect sound and communicate underwater is important for a variety of Steller sea lion life functions, including reproduction and predator avoidance. Loud anthropogenic sounds can interfere with Steller sea lion auditory capabilities. Steller sea lions are categorized in the Otariid pinniped (OW) functional hearing group (Southall et al. 2007). Studies of Steller sea lion auditory sensitivities have found that this species detects sounds underwater between 1 to 25 kHz (Kastelein et al. 2005), and sounds in the air between 0.25 to 30 kHz (Mulsow and Reichmuth 2010).

4.2.11.5 Stressors/Threats

Complete descriptions of stressors to the western DPS of Steller sea lions are provided in the recovery plan (NMFS 2008).

4.2.11.5.1 Fisheries interactions

Between 2010-2014, there were incidental serious injuries and mortalities of western Steller sea lions observed in 8 federal fisheries: BSAI Atka mackerel trawl, BSAI flatfish trawl, BSAI Pacific cod trawl, BSAI pollock trawl, BSAI Pacific cod longline, Gulf of Alaska Pacific cod trawl, Gulf of Alaska Pacific cod longline, and Gulf of Alaska sablefish longline (Muto et al.

2017). In the early 1990s, observers monitoring the Prince William Sound salmon drift gillnet recorded 2 Steller sea lion mortalities (Wynne et al. 1992). The current rate of incidental mortality and serious injury for this salmon fishery is not known. Overall, the estimated mean annual mortality and serious injury rate from U.S. commercial fisheries is 30 sea lions per year (Muto et al. 2017).

Entanglement or other interactions with fishing gear is another source of Steller sea lion mortality or injury. During 2010-2014, the minimum annual mortality and serious injury rate for this stock was estimated at 1.6 animals. This estimate is considered a minimum because not all entangled animals strand and not all stranded animals are found or reported (Muto et al. 2017). Based on observer data (29.6) and stranding data (0.8), the minimum estimated mortality rate incidental to commercial and recreational fisheries is 30.4 (Allen and Angliss 2014).

The minimum average annual mortality and serious injury rate for all fisheries based on observer data, stranding data, and from other unknown fisheries (recreational, subsistence, or commercial) is 32 animals per year (Muto et al. 2017).

4.2.11.5.2 Subsistence harvest

The mean annual subsistence take (harvested plus struck-and-lost) from this DPS from 2004 through 2008, combined with the mean take over the 2010-2014 period from St. Paul Island, is 201 western DPS Steller sea lions harvested Alaska-wide per year (Muto et al. 2017).

4.2.11.5.3 Marine debris or other human interactions

Reports from the NMFS stranding database of Steller sea lions entangled in marine debris or with injuries caused by other types of human interaction are another source of mortality data. From 2010-2014, 11 animals were observed entangled in marine debris and 2 with other human-related injuries. The mean annual mortality and serious injury from other sources of human interactions for 2010-2014 is 2.6 animals (Muto et al. 2017).

4.2.11.5.4 Illegal harvest

Illegal harvest of the western DPS of Steller sea lions is known to occur, but to an unknown extent. Western DPS Steller sea lions with suspected gunshot wounds have been found stranded on shore along the outer Copper River Delta as recently as 2016 (NMFS unpublished data). Two men were convicted and sentenced in federal court in 2018 for harassing and killing Steller sea lions by gunshot and obstructing the government's investigation into their criminal activities.

4.2.11.5.5 Research activities

Mortalities may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Between 2010-2014, there were 2 mortalities resulting from research on western DPS Steller sea lions resulting in a mean annual mortality and serious injury rate of 0.4 animals per year (Muto et al. 2017).

4.2.11.5.6 Other stressors

Other stressors may include nutritional stress related to competition with commercial fisheries or environmental change, predation by killer whales, toxic substances, disease and parasitism, disturbance from vessel traffic and tourism, and environmental variability, which may potentially be affecting recovery (Muto et al. 2017; NMFS 2008).

4.3 Status of Listed Species—Fish

For Pacific salmon and sturgeon, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These “viable salmonid population” (VSP) criteria therefore encompass the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. When a population or species has sufficient spatial structure, diversity, abundance, and productivity, it will generally be able to maintain its capacity to adapt to various environmental conditions and sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species’ entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

“Spatial structure” refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population’s spatial structure depends fundamentally on habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population.

“Diversity” refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000).

“Abundance” generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).

“Productivity,” as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms “population growth rate” and “productivity” interchangeably when referring to production over the entire life cycle. They also refer to “trend in abundance,” which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species’ populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread (to avoid concurrent extinctions from mass catastrophes) and spatially close (to allow functioning as metapopulations) (McElhany et al. 2000).

A species' status thus is a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species' status. Information on the status and distribution of all the fish species considered here can be found in a number status reviews available on the NMFS West Coast Region's website,[12] most importantly for this opinion, the Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Northwest (Ford 2011) and the status reviews prepared in 2016. For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild.

Table 10. Listed fish species considered in this Biological Opinion. No listed fish species has critical habitat in Alaska.

Species	Population Unit (ESU or DPS)	Status	Listing	Critical Habitat
Green Sturgeon (*Acipenser medirostris)*	Southern DPS	Threatened	71 FR 17757 April 7, 2006	74 FR 52300 October 9, 2009
Chinook salmon (*Oncorhynchus tshawytscha*)	Lower Columbia River ESU	Threatened	70 FR 37160 June 28, 2005	70 FR 52630 September 2, 2005
	Upper Columbia River spring-run ESU	Endangered	70 FR 37160 June 28, 2005	70 FR 52630 September 2, 2005
	Puget Sound ESU	Threatened	70 FR 37160 June 28, 2005	70 FR 52630 September 2, 2005
	Snake River fall-run ESU	Threatened	70 FR 37160 June 28, 2005	58 FR 68543 December 28, 1993
	Snake River spring/summer-run ESU	Threatened	70 FR 37160 June 28, 2005	58 FR 68543 December 28, 1993
	Upper Willamette River ESU	Threatened	70 FR 37160 June 28, 2005	70 FR 52630 September 2, 2005
Chum salmon *(Oncorhynchus keta)*	Hood Canal summer-run ESU	Threatened	70 FR 37160 June 28, 2005	70 FR 52630 September 2, 2005
	Columbia River ESU	Threatened	70 FR 37160 June 28, 2005	70 FR 52630 September 2, 2005
Coho salmon *(Oncorhynchus kisutch)*	Lower Columbia River ESU	Threatened	70 FR 37160 June 28, 2005	81 FR 9252 February 24, 2016
Sockeye salmon *(Oncorhynchus nerka)*	Lake Ozette ESU	Threatened	70 FR 37160 June 28, 2005	70 FR 52630 September 2, 2005
	Snake River ESU	Endangered	70 FR 37160 June 28, 2005	58 FR 68543 December 28, 1993

[12] Available at http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/status_reviews.html, Accessed October 19, 2017.

Salmonids

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids. NMFS' status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). Very generally, these include habitat degradation and curtailment caused by human development and harvest and hatchery practices. NMFS' decision to list each species identified a variety of factors that were limiting their recovery. None of these documents identifies scientific research as either a cause for decline or a factor preventing their recovery.

Status in the Marine Environment

Despite the importance of the marine phase of their life-cycle, there is little known about the status of the ESA-listed salmon while in the marine waters. Once salmon leave their natal rivers, they are difficult the track. Chinook salmon generally migrate out of their natal rivers within six months to a year of emergence and will spend one to seven years at sea. Coho will spend about 18 months in fresh water and approximately 6 or 18 months in the marine environment. Very little is known about steelhead in the ocean as they are rarely encountered or recovered in ocean salmon fisheries. Information on salmon abundance and distribution once they leave fresh water is based upon the recovery of salmon with coded wire tags (CWTs) in ocean fisheries.

The marine distribution and relative abundance of specific stocks, including ESA-listed salmonids, has been modeled using a representative hatchery stock (or stocks) to serve as proxies for the wild and hatchery fish within the ESUs. This assumes that hatchery and wild stocks have similarities in life histories and migrations in marine waters. The validity of using a hatchery stock as a proxy for a wild stock has been brought up as a serious issue in ocean salmon fisheries management. Differences in the performance, survival, behavior, and physical condition between natural and hatchery-origin salmonids have been identified innumerous studies (see Chittenden et al. (2009) for a review of some references). However, studies have focused on features associated with relative fitness with regard to early-life dynamics. Once in the marine environment, there is little evidence of exactly how these differences influence movement or exposure to harvest in fisheries. After examining nearly 2 million CWT recovery locations, Weitkamp and Neely (2002) found consistency between natural and hatchery coho CWT recovery patterns on the North American west coast, and concluded the use of hatchery populations as a proxy for marine distribution for coho was reasonable.

Other Factors Affecting Salmonids

Beyond the impacts of fisheries described above, at-sea survival of salmon can be affected by a number of manmade and natural factors once they reach the marine environment. Juvenile salmon are prey for marine seabirds, marine mammals, and larger fish. Adult salmon are prey to pinnipeds such as sea lions, harbor seals, and killer whales.

The environmental conditions at the time of ocean entry and near the point of ocean entry are likely to be especially important in determining the survival of juvenile Chinook (Lindley et al. 2009). If ocean productivity and feeding conditions are good, growth will be high and starvation or the effects of size-dependent predation may be lower. Recent studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions (Peterson et al. 2006; Wells et al. 2008). The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of the role they play in salmon survival in the ocean.

There is evidence to suggest that salmon abundance is linked to variation in climate effects on the marine environment. It is widely understood that variations in marine survival of salmon correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm ones unfavorable (Behrenfeld et al. 2006; Wells et al. 2006). Both short term El Nino Southern Oscillation and longer term climate variability, Pacific Decadal Oscillation, appear to play a part in salmon survival and abundance.

Southern DPS Green Sturgeon

Green sturgeon occur in the southern end of the action area. Impacts to this portion of the action area are described below and include disturbance of benthic habitats and communities, reductions in water quality (contaminants, increased sedimentation, and turbidity), and increased levels of underwater noise. Southern DPS green sturgeon also occur in Puget Sound.

Other Human Sources of Injury: Several ocean dredged material disposal sites have been designated within the range of ESA-listed green sturgeon. NMFS consults with the EPA on the proposed designation of these sites, as well as on the issuance of permits by the EPA for disposal activities at these sites. NMFS concluded that the proposed actions were likely to adversely affect but not likely to jeopardize the continued existence of the Southern DPS green sturgeon. The disposal of dredged materials at these disposal sites has the potential to entrain and bury small (*i.e.*, ≤ 2 feet in length) subadult green sturgeon that, unlike adults and larger subadults, may not be able to move quickly enough to avoid descending sediments. This may result in injury to small subadult green sturgeon, but the number affected was expected to be low given the location of the disposal sites and the migratory patterns of green sturgeon in marine waters (*e.g.*, green sturgeon are likely to spend limited time in one area as they move from estuary to estuary).

Underwater noise generated from in-water construction activities has the potential to cause injury to fish species such as green sturgeon; however, there is limited information available to assess these effects. In 2011, NMFS consulted on the proposed Columbia River Jetty System

Rehabilitation Project at the mouth of the Columbia River (NMFS 2011b). NMFS concluded that the proposed action was likely to adversely affect but not likely to jeopardize the continued existence of the Southern DPS green sturgeon. Although pile driving and removal activities associated with the project could result in underwater noise effects on green sturgeon, the sound levels generated by the project were expected to be below estimated threshold levels that would result in injury to fish. NMFS expected that few, if any, green sturgeon would be in close proximity to the jetties and concluded that the activities were not likely to result in behavioral responses of green sturgeon that were in the action area. To minimize effects, NMFS recommended limiting activities to a few days or a single event annually.

Prey Availability: The feeding habits and diet of green sturgeon in the ocean is poorly known, but they may prey upon demersal fish (sand lance are a known diet item) captured in bottom trawl fisheries. Disturbance of benthic habitats by bottom trawl fisheries may also affect prey species and alter the abundance, distribution, and composition of benthic communities. How these changes may affect Southern DPS green sturgeon is unclear, however, because some of these benthic communities are in high energy environments characterized by frequent disturbance and rapid recolonization. In addition, it is unclear whether disturbance of benthic habitats by bottom trawls may reduce or enhance feeding opportunities for green sturgeon. Also, green sturgeon feeding while in marine waters and the prey resources they may feed on have not yet been confirmed or identified. Thus, effects of fishing activities on prey availability in designated green sturgeon critical habitat and feeding opportunities for green sturgeon are difficult to evaluate until more definitive information is known about the marine habitat use and diets of green sturgeon.

Finally, climate change may alter conditions in coastal marine waters and result in shifts in the distribution of prey resources for green sturgeon in coastal marine areas. We are limited in our ability to assess the effects of climate change on green sturgeon critical habitat, however, because of the limited information available regarding green sturgeon habitat use in coastal marine waters. In addition, variation in the effects of climate change on the marine environment adds to the uncertainty. For example, the effects of climate change may cause some species to increase in abundance and expand in distribution, whereas other species may decline in abundance and become more restricted in distribution.

4.3.1 Sturgeon and Salmonid Critical Habitat

Critical habitat has been designated for ESA-listed salmon and steelhead, as well as the southern DPS of green sturgeon (Table 7 and

Table 10). Those critical habitat designations do not extend to the action area of this consultation. Therefore, the actions being considered in this consultation would not affect salmon, steelhead, or southern green sturgeon critical habitat.

4.3.2 Green Sturgeon (*Acipenser medirostris*)

4.3.2.1 Population Structure, Distribution, and Conservation Status

The green sturgeon, *Acipenser medirostris*, is the most widely distributed member of the sturgeon family Acipenseridae. Like all sturgeons, green sturgeon are anadromous, but are considered to be the most marine-oriented of the sturgeons (Adams et al. 2002). Two DPSs of green sturgeon are recognized based on genetic data and spawning locations: (1) a Northern DPS consisting of populations originating from coastal watersheds north of and including the Eel River (i.e., the Klamath and Rogue rivers); and (2) a Southern DPS consisting of populations originating from coastal watersheds south of the Eel River, with the only known spawning population in the Sacramento River (68 FR 4433; January 29, 2003).

On April 7, 2006, NMFS listed the Southern DPS of green sturgeon as threatened under the ESA (71 FR 17757). Based on the 2005 status review, NMFS concluded that the Northern DPS did not warrant listing under the ESA, but designated the species as a NMFS Species of Concern (70 FR 17386; April 6, 2005). A recovery plan has not been prepared for the southern DPS of green sturgeon. Critical habitat for the Southern DPS of green sturgeon was designated on October 9, 2009 (74 FR 52300). There is no reliable population estimate or trend for the Southern DPS of green sturgeon.

4.3.2.2 Distribution

Green sturgeon spend a large portion of their lives in coastal marine waters as sub-adults and adults. Therefore, the marine distribution of both DPSs is considerably larger than the limited freshwater habitat, and the marine distribution extends from Mexico into Alaska (Figure 21).

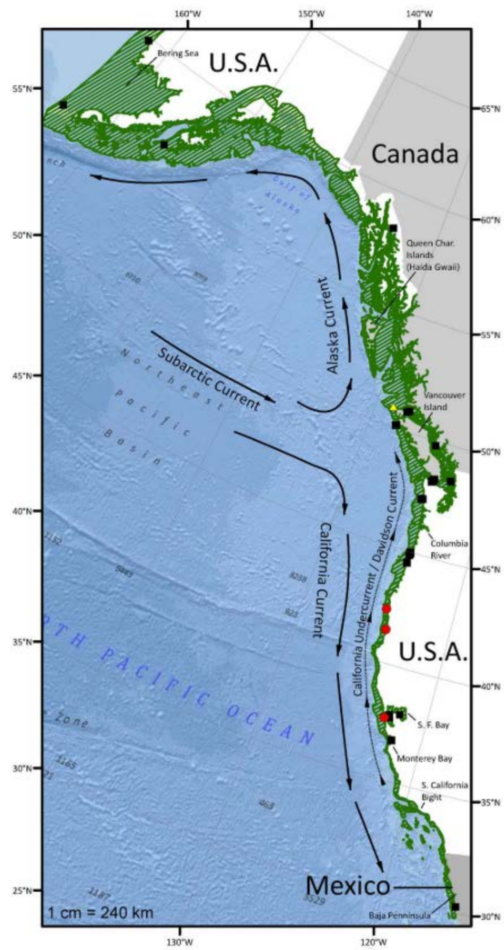

Figure 21. Distribution of green sturgeon along the West Coast of North America (from Huff et al. 2012). Black squares denote locations of green sturgeon presence records used in the study. Red circles denote spawning river mouths.

The distributions of the northern and southern DPSs of green sturgeon outside of natal waters generally overlap (Erickson and Hightower 2007; Lindley et al. 2008; Moser and Lindley 2007). Both Northern DPS and Southern DPS green sturgeon occupy coastal estuaries and coastal marine waters from southern California to Alaska, including Humboldt Bay, the lower Columbia River estuary, Willapa Bay, Grays Harbor, and coastal waters between Vancouver Island, British Columbia, and southeast Alaska (Israel et al. 2009; Lindley et al. 2008; Moser and Lindley 2007).

Generally, green sturgeon inhabit estuaries on the northern California, Oregon, and Washington coasts during the summer, and move to coastal marine waters along the central California coast and waters off of Vancouver Island and southeast Alaska over the winter (Lindley et al. 2008). Green sturgeon likely inhabit these estuarine and marine waters to feed and to optimize growth (Moser and Lindley 2007). The large aggregations of these fish that occur in the Columbia River estuary and Washington estuaries include green sturgeon from all known spawning populations (Moser and Lindley 2007). Fish tagging and telemetry data and genetic analyses suggest that

Southern DPS green sturgeon generally occur from Vancouver Island to Monterey Bay, California (Lindley et al. 2011; Lindley et al. 2008; Moser and Lindley 2007) and within this range, most frequently occur in coastal waters of Washington, Oregon, and Vancouver Island and near San Francisco and Monterey bays (Huff et al. 2012).

The Southern DPS at present contains only a single spawning population in the upper Sacramento River. Recent habitat evaluations conducted in the upper Sacramento River for salmonid recovery planning have indicated that significant green sturgeon habitat was probably altered or made inaccessible by dam construction (NMFS 2015e). Northern DPS green sturgeon primarily spawn in the Rogue River in Oregon and the Klamath-Trinity system in California and occupy coastal areas from Mexico to Alaska.

4.3.2.3 Critical Habitat

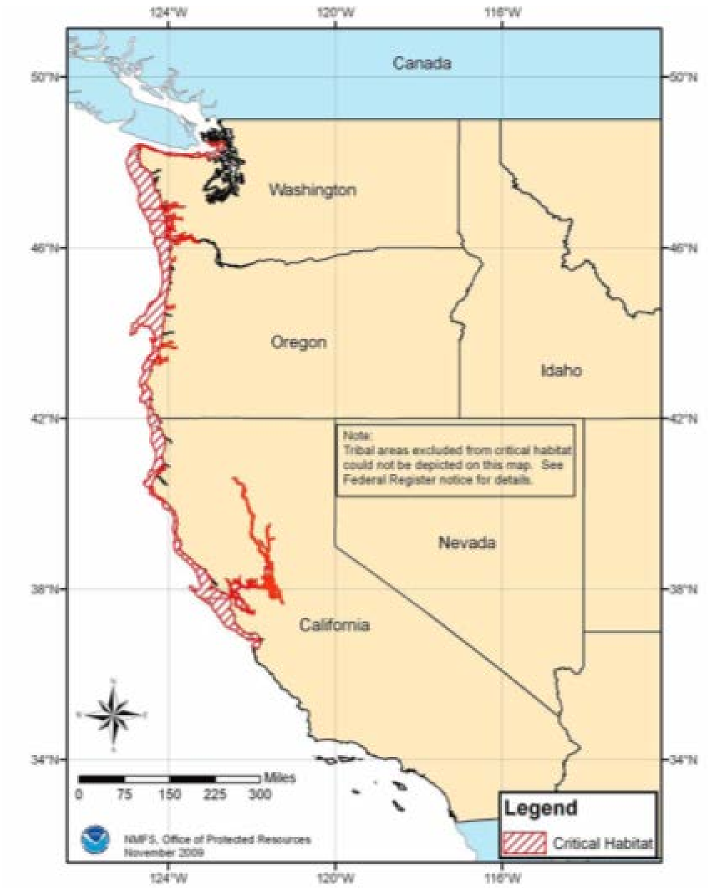

Figure 22. Designated Critical Habitat for the Southern DPS of Green Sturgeon

NMFS designated critical habitat for the threatened Southern DPS on October 9, 2009 (74 FR 52300) (Figure 22). In freshwater, designated critical habitat includes the mainstream Sacramento River downstream of Keswick Dam (including the Yolo and Sutter bypasses), the Feather River below Oroville Dam, the Yuba River below Dagueere Point Dam, and the Sacramento-San Joaquin Delta. In marine waters, designated critical habitat includes areas inland of the 60 fathom (110 m) depth isobath from Monterey Bay to the U.S.-Canada border. In coastal bays and estuaries, designated critical habitat includes San Francisco Bay Estuary and Humboldt Bay in California; Coos, Winchester, Yaquina, and Nehalem bays in Oregon; Willapa Bay and Grays Harbor in Washington; and the lower 74 km of the Columbia River and estuary. Critical habitat for the Southern DPS does not include marine waters of Alaska.

4.3.2.4 Distribution in Alaska

The green sturgeon is infrequently encountered at the extreme boundaries of its range (Colway and Stevenson 2007; Rosales-Casian and Almeda-Jauregui. 2009). In Alaska, green sturgeon are listed as a "nominee" species in the State of Alaska Wildlife Action Plan and designated as a "Species of Greatest Conservation Need" under the Aquatic Habitat Implementation Plan, which is part of the Comprehensive Wildlife Conservation Strategy (NMFS 2015e). The ADFG indicates that information about green sturgeon presence is limited to a few anecdotal reports of sightings and captures in State of Alaska waters, occurring mostly in southeastern Alaska (encompassing the mouths of the Stikine and Taku rivers). ADFG has received no reports of recurrent sightings of sturgeon.

Studies confirm that North American green sturgeon are rare in Alaskan waters (NMFS 2015e). Lindley et al. (2008) tagged 213 sub-adult and adult Northern and Southern DPS green sturgeon from Oregon, Washington, and California and observed only one tagged green sturgeon taken in a commercial gillnet fishery in southeast Alaska, further supporting the assumption that green sturgeon only rarely enter Alaskan waters. The tagged green sturgeon was later confirmed as belonging to the Southern DPS (NMFS 2015e).

The North Pacific Groundfish Observer Program, which observes federal groundfish fisheries off Alaska within the action area, has recorded rare encounters with green sturgeon in trawl fisheries in the Bering Sea for over three decades (1982:1; 1984:2; 2005:1; 2006:3; 2009:1; 2012:1; 2013:1; 2015:1l; reported in NMFS (2015e)). It is unknown whether these green sturgeon belonged to the Northern DPS or the Southern DPS. However, it follows that given the reduced scale of the research surveys as compared to the commercial fisheries that encounters with sturgeon would be even less likely in the research program. In fact, during the same three decade period there have been no takes of green sturgeon reported from any of the fishery surveys considered in the proposed action.

4.3.2.5 Natural History

The green sturgeon is an anadromous fish that occurs in the nearshore Eastern Pacific Ocean from Alaska to Mexico (Moyle 2002). They are long lived, late maturing, spawn infrequently in natal streams, and spend substantial portions of their lives in marine waters. Green sturgeon reach sexual maturity at approximately fifteen years of age (Van Eenennaam et al. 2006), and may spawn every three to five years throughout their long lives. The Southern DPS of green sturgeon spawn in the upper mainstem Sacramento River in cool (14-17º C), deep, turbulent areas with clean, hard substrates. Larvae and juveniles migrate downstream toward the Sacramento-San Joaquin Delta/Estuary, where they rear for one to four years before migrating out to the Pacific Ocean as subadults. Once at sea, subadults and adults occupy coastal waters to a depth of 110 m from Baja California, Mexico, to the Bering Sea, Alaska (Erickson and Hightower 2007). Seasonal migrations are known to occur. Fish congregate in coastal bays and estuaries of Washington, Oregon, and California during summer and fall. In winter and spring, similar aggregations can be found from Vancouver Island to Hecate Strait, British Columbia, Canada (Lindley et al. 2011; Lindley et al. 2008). Green sturgeon are benthic feeders and may also eat small fish (Moyle 2002). More information on the life history of green sturgeon is provided in the proposed rule to list this DPS under the ESA (70 FR 17386; April 6, 2005) and the most recent status review (NMFS 2015e).

4.3.2.6 Stressors/Threats

The principal cause of decline and current threat to the Southern DPS of green sturgeon is the reduction of historically accessible spawning habitat, most notably by impoundments (NMFS 2010b). Additional threats to green sturgeon include freshwater habitat alteration, impaired water quality, dredging and ship traffic, ocean energy development, incidental catch in recreational and commercial fisheries, poaching, scientific research, disease, predation, displacement by non-native invasive species, inadequacy of existing regulatory mechanisms, and entrainment of larvae and juveniles in water diversions (NMFS 2010b).

4.3.3 Lower Columbia River Chinook

Description and Geographic Range: Lower Columbia River (LCR) Chinook salmon were listed as threatened on March 24, 1999 (64 FR 14308). NMFS re-examined the status of these fish in 2005, 2011, and 2016 and determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). The ESU is comprised of all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River. The ESU also includes fifteen artificial propagation programs (79 FR 20802; April 14, 2014).

The Lower Columbia River salmon recovery plan (NMFS 2013d) identifies 31 historical demographically independent populations in three strata for the LCR Chinook salmon ESU (Table 11). The strata are groups of populations with similar life history traits within the same ecological zone. Within the LCR Chinook salmon ESU, run timing was the predominant life history criteria used in identifying populations. The recovery plans identify three distinct run times: spring, fall, and late fall. The distribution of populations with distinct run times varies among the three ecological subregions. Fall-run Chinook salmon historically were found throughout the Lower Columbia River Chinook Salmon ESU, while spring-run Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries). Late fall-run Chinook salmon populations are found in only two basins in the Cascade strata. In general, late fall-run Chinook salmon also mature at an older average age than either lower Columbia River spring- or fall-run Chinook salmon, and have a more northerly oceanic migration route.

Table 11. Historical Population Structure and Viability Status for Lower Columbia River Chinook Salmon (VL=very low, L=low, M=moderate, H=high, VH=very high)(NMFS 2013d).

Stratum (Run)	**Population**	**Viability Status**		
		A&P	**Spatial**	**Diversity**
Coastal (Fall)	Youngs	L	VH	L
	Grays/Chinook	VL	H	VL
	Big Creek	VL	H	L
	Elochoman/Skamokowa	VL	H	L
	Clatskanie	VL	VH	L
	Mill/Abernathy/Germany	VL	H	L
	Scappoose	L	H	L
Cascade (Fall)	Coweeman	VL	H	H
	Lower Cowlitz	VL	H	M
	Upper Cowlitz	VL	VL	M
	Toutle	VL	H	M
	Kalama	VL	H	M
	Lewis	VL	H	H
	Clackamas	VL	VH	L
	Washougal	VL	H	M
	Sandy	VL	M	L
Columbia Gorge (Fall)	Lower gorge	VL	M	L
	Upper gorge	VL	M	L
	Hood	VL	VH	L
	Big White Salmon	VL	L	L
Cascade (Late Fall)	Sandy	VH	M	M
	North Fork Lewis	VH	H	H
Cascade (Spring)	Upper Cowlitz	VL	L	M
	Cispus	VL	L	M
	Tilton	VL	VL	VL
	Toutle	VL	H	L
	Kalama	VL	H	L
	Lewis	VL	L	M
	Sandy	M	M	M
Gorge (Spring)	Big White Salmon	VL	VL	VL
	Hood	VL	VH	VL

Spatial Structure and Diversity: LCR Chinook salmon exhibit both spring- and fall-run life histories. Some emigrate to the ocean as subyearlings, but some spring-run populations may have a large proportion of yearling migrants. Chinook populations in the Lower Columbia tend to mature at ages 3 and 4, but there is a considerable range in age at maturity. For example, “tule” fall-run Chinook salmon return at ages 3 and 4; and “bright” fall-run Chinook return at ages 4 and 5, with substantial numbers returning at age 6. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater areas throughout the range of the listed species. Parr usually undergo a smolt transformation as subyearlings at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams.

The recovery plan (NMFS 2013d) rates diversity as low to very low in 18 out of 31 populations (Table 11). The NWFSC found that diversity of LCR Chinook has been affected by the loss of 80% of the spring run populations, the high proportion of hatchery fish on the spawning grounds, and habitat loss and degradation (Ford 2011; Good et al. 2005; NMFS 2015f) . On average fall-run Chinook salmon hatchery programs have released 50 million fish annually, with spring-run and upriver bright (URB) programs releasing a total of 15 million fish annually (NMFS 2015f). Furthermore, due to these high levels of hatchery production and corresponding low levels of natural production, many of the populations contain over 50% hatchery fish among their naturally spawning assemblages (NMFS 2015f).

In addition to the disparity between natural production and hatchery production, the release of out-of-ESU hatchery stocks continues to be an issue in several areas of the ESU. Hatchery programs in Youngs Bay and Big Creek release out-of-ESU stocks from the Rogue River and Upper Willamette River. Hatchery programs in the Columbia Gorge release fall-run Chinook from the upriver bright stock, and a program in the Hood River has adopted an out-of-ESU spring-run Chinook stock from the Deschutes River.

The Oregon and Washington recovery plans rate spatial structure as moderate to very high in 24 out of 31 populations (Table 11). The populations that rate lowest have fish passage barriers. Trap and haul operations on the Cowlitz River pass adults upriver, but downstream passage and survival of juvenile fish is very low. This problem also affects spatial structure in the Cispus and Tilton populations. Merwin Dam blocks access to most of the available spawning habitat in the North Fork Lewis populations. However, the relicensing agreement for Lewis River hydroelectric projects calls for reintroduction of Chinook salmon. Condit Dam on the White Salmon River blocked access to most of the historical spawning habitat but was removed in 2011. Thus, the recovery plans rate LCR Chinook salmon spatial structure as moderate to very high for more than two thirds of the populations, and for three populations with low ratings, management actions are underway to improve the situation (fall and spring runs in the White Salmon River and the spring run in the Lewis River).

Abundance and Productivity: Ford (2011) found that abundance of all LCR Chinook salmon populations increased during the early 2000s but by the end of the decade had declined back to levels observed in 2000 for all but one population. In general, abundance of LCR Chinook salmon populations has not changed considerably since the previous status reviews. Of the 31 populations in this ESU, the NMFS (2015f) found only the 2 late-fall run populations (Lewis River and Sandy River) to be viable or nearly so. With a few exceptions, the remainder of the populations fall-run far short of their recovery goals in abundance (NMFS 2015f).

In 1998, NMFS assessed the abundance in smaller tributary streams in the range of the species to be in the hundreds of fish (Myers et al. 1998). Larger tributaries (e.g., Cowlitz River basin) contained natural runs of Chinook salmon ranging in size from 100 to almost 1,000 fish. In 2005, NMFS calculated adult abundance using the geometric mean of natural-origin spawners in the five years previous to 2003 (Good et al. 2005). In 2005, NMFS estimated the LCR Chinook salmon abundance at approximately 14,130 fish (Good et al. 2005). Data that are more recent place the abundance of naturally produced LCR Chinook salmon at approximately 13,594 spawners (Table 12).

Table 12. 5-year Average Abundance Estimates for LCR Chinook Salmon Populations[13,14]

Stratum (Run)	Population	Years	Total	HOR(1)	NOR(2)
Coastal (Fall)	Youngs Bay	2012-2014	5,839	5,606	233
	Grays/Chinook	2010-2014	457	357	100
	Big Creek	2012-2014	1,542	1,510	32
	Elochoman/Skamokowa	2010-2014	696	580	116
	Clatskanie	2012-2014	3,291	3,193	98
	Mill/Abernathy/Germany	2010-2014	897	805	92
Cascade (Fall)	Lower Cowlitz	2010-2013	919	196	723
	Upper Cowlitz	2010-2013	3,834	961	2,873
	Toutle	2010-2014	8,705	5,400	3,305
	Coweeman	2010-2014	1,348	963	385
	Kalama	2010-2014	9,694	8,892	803
	Lewis	2010-2014	3,121	943	2,178
	Washougal	2010-2014	309	116	192
	Clackamas	2012-2014	4,227	2,955	1,272
	Sandy	2012-2014	1,527	320	1,207
Columbia Gorge (Fall)	Lower gorge	2003-2007	146	Unknown	146
	Upper gorge	2010-2012	527	327	200
	White Salmon	2010-2014	1,075	246	829
Cascade (Late Fall)	North Fork Lewis	2010-2014	12,330	0	12,330
Cascade (Spring)	Upper Cowlitz/Cispus	2010-2014	3,893	3,614	279
	Kalama	2011-2014	115	na	115
	North Fork Lewis	2010-2014	217	0	217
	Sandy	2010-2014	3,201	1,470	1,731
Gorge (Spring)	White Salmon	2013-2014	152	140	13
Total			**68,061**	**38,594**	**29,469**
(1) Hatchery Origin (HOR) spawners. (2) Natural Origin (NOR) spawners.					

[13] Data available from ODFW Oregon Adult Salmonid Inventory and Sampling Project (http://odfw.forestry.oregonstate.edu/spawn/index.htm).
[14] Data available from WDFW Salmonid Stock Inventory Populations (https://data.wa.gov).

The recovery plan (NMFS 2013d) rates all but three Chinook populations as low to very low for abundance and productivity (Table 11). The range of abundance recommended for recovery is from 300 (Kalama spring-run) to 7,300 (North Fork Lewis late fall-run). Current abundance estimates from WDFW and ODFW suggest that only five populations are at or have exceeded abundance goals, and for one of these (the White Salmon River), we do not know what portion of the spawners are hatchery origin.

The average annual outmigration of LCR Chinook salmon arriving at various locations in the Columbia River basin for the years 2012-2016 is shown in Table 13 (R. Zabel, NWFSC, unpublished data, 2013-2016).

Table 13. Average Estimated Outmigration for Listed LCR Chinook Salmon (2012-2016).

Origin	Outmigration
Natural	12,866,892
Listed hatchery intact adipose	1,150,536
Listed hatchery adipose clip	35,298,675

The number of natural fish should be viewed with caution. Estimating juvenile abundance is complicated by a host of variables: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Limiting Factors: The status of lower Columbia River salmon results from the combined effects of habitat degradation, dam building and operation, fishing, hatchery operations, ecological changes, and natural environmental fluctuations. Habitat for LCR Chinook has been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, channel alternations, and floodplain interactions. These large-scale changes have altered habitat conditions and processes important to migratory and resident fish and wildlife. Additionally, habitat conditions have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. Lower Columbia salmon are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes in impoundments. Dams in many of the larger subbasins have blocked anadromous fishes' access to large areas of productive habitat.

Harvest is unique among the limiting factors in that it is both a goal of recovery and a factor that can limit recovery. The compounding effects of high fishery mortality coupled with substantial habitat and ecosystem alteration has reduced the numbers, distribution, resilience, and diversity of LCR Chinook salmon throughout the lower Columbia region (NMFS 2013d). In response to the species listing, ocean and lower Columbia freshwater commercial and recreational fisheries have been substantially reduced as a result of international treaties, fisheries conservation acts, regional conservation goals, the Endangered Species Act, and state and tribal management agreements. The recovery plan identifies a strategy that continues to restrict and further reduce fishery impacts on listed wild fish (NMFS 2013d).

Hatchery programs can harm salmonid viability in several ways: hatchery-induced genetic change can reduce fitness of wild fish; hatchery-induced ecological effects—such as increased competition for food and space—can reduce population productivity and abundance; hatchery imposed environmental changes can reduce a population's spatial structure by limiting access to historical habitat; and hatchery-induced disease conveyance can reduce fish health. Practices that introduce native and non-native hatchery fish can increase predation on juvenile life stages. Hatchery practices that affect natural fish production include removal of adults for broodstock, breeding practices, rearing practices, release practices, number of fish released, reduced water quality, and blockage of access to habitat.

Status Summary: Despite the few years of high abundance observed in the early part of the last decade, the overall abundance of LCR Chinook salmon is still only a fraction of historical levels. In general, the populations do not show any dramatic changes in abundance or fraction of hatchery origin spawners since the 2005 status review (NMFS 2013d). High proportions of hatchery fish on the spawning grounds continue to threaten diversity of the LCR Chinook salmon ESU. The development and implementation of stock transfer policies in Oregon and Washington may help reduce artificial production's effects on natural fish. However, the process is just starting, and more time is needed before we can know the effect of these actions. Trap and haul programs have begun to re-introduce Chinook salmon to many miles of habitat, potentially improving the spatial structure and diversity of the species.

4.3.4 Upper Columbia River Spring-run Chinook

Description and Geographic Range: On March 24, 1999, NMFS first listed Upper Columbia River (UCR) spring-run Chinook salmon as an endangered species under the ESA (64 FR 14308). In that listing determination, NMFS concluded that the UCR spring-run Chinook salmon were in danger of extinction throughout all or a significant portion of their range. When NMFS re-examined the status of the UCR Chinook in 2005 (70 FR 37160; June 28, 2005), we came once again to the conclusion that the species warranted listing as endangered. On August 15, 2011, NMFS announced the results of an ESA 5-year review concerning UCR spring-run Chinook salmon (76 FR 50448). After reviewing new information on the viability of this species, ESA section 4 listing factors, and efforts being made to protect the species, NMFS concluded that this species should retain its endangered listing classification. Another review was completed in 2015 and, given the same considerations, the 2015 status review team found that while there had been some improvement in a number of areas, the risk categories for this species remained unchanged from the previous review (NMFS 2015f) (81 FR 33468; May 26, 2016). Further, they rated the species overall risk trend as stable. A recovery plan is available for this species (Upper Columbia Salmon Recovery Board 2007).

Spatial Structure and Diversity: The UCR spring-run Chinook salmon inhabit tributaries upstream from the Yakima River to Chief Joseph Dam. Adult UCR Chinook return to the Wenatchee River from late March through early May, and to the Entiat and Methow Rivers from late March through June. These three areas comprise the species' three populations—there was one other considered, the Okanogan, but it was determined to have been extirpated. Most adults return after spending two years in the ocean, although 20 percent to 40 percent return after three years at sea. Peak spawning for all three populations occurs from August to September. Smolts typically spend one year in freshwater before migrating downstream. There are slight genetic differences between this species and others containing stream-type fish, but more importantly, the ESU boundary was defined using ecological differences in spawning and rearing habitat (Myers et al. 1998). The Grand Coulee Fish Management Program (1939 through 1943) may have had a major influence on this species' diversity because fish from multiple populations were mixed into one relatively homogenous group and redistributed into streams throughout the upper Columbia River region. Currently, approximately 65% of the fish retuning to this ESU are hatchery fish. NMFS originally determined that six hatchery stocks in the UCR basin (Chiwawa, Methow, Twisp, Chewuch, and White Rivers and Nason Creek) should be included as part of the species because they were considered essential for recovering the fish (64 FR 14308; March 24, 1999). The artificially propagated stocks changed slightly in the subsequent review, in that the Winthrop composite stocks were listed and the Nason Creek stock was not (70 FR 37160; June 28, 2005). The ICTRT identified no major population groups (MPGs) due to the relatively small geographic area affected (Ford 2011; NMFS 2011a) (Table 14).

Table 14. Scores for the key elements (A&P, diversity, and SS/D) used to determine current overall viability risk for spring-run UCR Chinook salmon (NMFS 2015f). Risk ratings included very low (VL), low (L), moderate (M), high (H), very high (VH), and extirpated (E).

Population	A&P	Diversity	Integrated SS/D	Overall Viability Risk
Wenatchee River	H	H	H	H
Entiat River	H	H	H	H
Methow River	H	H	H	H
Okanogan River				E

The integrated SS/D (spatial structure and diversity) risks are "high" for all three of the extant populations in this MPG. The spatial processes component of the SS/D risk is "low" for the Wenatchee River and Methow River populations and "moderate" for the Entiat River (loss of production in lower section increases effective distance to other populations). All three of the extant populations in this MPG are at “high” risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners in natural spawning areas and lack of genetic diversity among the natural-origin spawners (Ford 2011).

Increases in natural origin abundance relative to the extremely low spawning levels observed in the mid-1990s are encouraging; however, average productivity levels remain extremely low. Overall, the viability of UCR Spring-run Chinook salmon ESU has likely improved somewhat since the last status review, but the ESU is still clearly at “moderate-to-high” risk of extinction (Ford 2011).

Abundance and Productivity: The 1998 Chinook Status Review (Myers et al. 1998) reported that long-term trends in abundance for UCR spring-run Chinook populations were generally negative, ranging from -5% to +1%. Analyses of the data series, updated to include 1996-2001 returns, indicate that those trends have continued. The long-term trend in spawning escapement is downward for all three systems. The Wenatchee River spawning escapements have declined an average of 5.6% per year, the Entiat River population an average of 4.8% per year, and the Methow River population an average rate of 6.3% per year since 1958 (Good et al. 2005).

In the 1960s and 1970s, spawning escapement estimates were relatively high with substantial year-to-year variability. Escapements declined in the early 1980s, then peaked at relatively high levels in the mid-1980s. Returns declined sharply in the late 1980s and early 1990s. The 1900-1994 returns were at the lowest levels observed in the 40-plus years of the data sets, and from 1995 through 1999, the returns averaged 282 fish (Pacific Coastal Salmon Recovery Fund 2006).

The Upper Columbia Biological Requirements Workgroup (Ford 2011) recommended interim delisting levels of 3,750, 500, and 2,200 spawners for the populations returning to the Wenatchee, Entiat, and Methow drainages, respectively. Five-year geometric mean spawning escapements from 1997 to 2001 were at 8%-15% of these levels. Target levels have not been exceeded since 1985 for the Methow run and the early 1970s for the Wenatchee and Entiat populations (Good et al. 2005).

From 2006 through 2010, the five-year average return to the ESU—as measured primarily by spawning surveys--was 3,900 (Salmonid Population Summary (SPS) query, April 2014[15]); of these, approximately 65% were of hatchery origin. Counts at Rock Island Dam in 2008, 2010, and 2011 showed an average estimated 1,668 natural fish returning to the ESU which, given a 35% natural-origin for the overall return, indicated that the total return was on the order of 4,766 fish. (The counts did not differentiate between adipose-clipped fish hatchery and hatchery fish

[15] The data contained in the SPS database are primarily summary data, compiled at the population level. The database also includes a limited number of series representing the aggregate returns to groups of populations (e.g., Lower Granite Dam counts) or counts of spawners within a subsection of a population where expansions to the population level were not feasible.

with an intact adipose, and there is a data gap for the year 2009). The figures just quoted demonstrate that there is some degree of variability in the various sources for returning adult numbers. As a result, it is sometimes difficult to take all the various factors into account (survey types, data gaps, various dam counts, hatchery vs. wild components, etc.) and clearly and accurately determine what the returns actually are. Nonetheless, the figures we believe to be the most likely to represent the actual returns come from the U.S. v. Oregon Technical Advisory Committee numbers derived from dam counts and compiled by the WDFW[13]. These numbers are widely used throughout the region for management purposes (particularly in setting harvest quotas), and at this point represent the best available scientific and technical knowledge to which we have access. The most recent year for which these numbers have been calculated and published is 2014 from NMFS' Adaptive Management Implementation Plan[16] That year, the UCR Chinook total return to Rock Island Dam was 3,986 natural adults. The most recent four-year average to that date was 3,170 fish. Given that these fish comprise approximately 35% of the total run, it signifies that the total return for 2014 was 11,388 fish and the most recent four year average was 9,057 adults.

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the UCR spring-run Chinook juvenile outmigration are displayed below.

Table 15. Recent Five-Year Average Projected Outmigrations for UCR Chinook (Dey and Zabel, NWFSC, unpublished data).

Origin	Outmigration
Natural	521,802
Listed Hatchery: Adipose Clipped*	507,920
Listed Hatchery: Intact Adipose*	592,379
*When the above species was listed, NMFS included certain artificially propagated (hatchery-origin) populations in the listing. Some of those listed fish have had their adipose fins clipped at their respective hatcheries and some have not.	

All three existing Upper Columbia River spring-run Chinook salmon populations have exhibited similar trends and patterns in abundance over the past 40 years. The 1998 Chinook salmon status review (Myers et al. 1998) reported that long-term trends in abundance for upper Columbia River spring-run Chinook salmon populations were generally negative, ranging from ‑5% to +1%. Analyses of the data series, updated to include 1996‑2001 returns, indicate that those trends have continued. The long-term trend in spawning escapement is downward for all three systems. Between 1958 and 2001, Wenatchee River spawning escapements declined at an average rate of 5.6% per year, the Entiat River population at an average of 4.8% per year, and the

[16] Available at https://www.salmonrecovery.gov/docs/FCRPS_IP_2014-1-10.pdf, Accessed November 14, 2017.

Methow River population at an average of 6.3% per year (Good et al. 2005). These rates of decline were calculated from the redd count data series. Out of the 12 sub-populations identified in the ESU, only two showed short-term increases in productivity between 1997 and 2001—though all other sub-populations were decreasing at slower rates than in the previous five years.

McClure et al. (2003) reported standardized quantitative risk assessment results for 152 listed salmon stocks in the Columbia River basin, including representative data sets (1980‑2000 return years) for upper Columbia River spring-run Chinook salmon. Average annual growth rate (λ) for the upper Columbia River spring-run Chinook salmon population was estimated at 0.85, the lowest average reported for any of the Columbia River ESUs analyzed in the study. Assuming that population growth rates were to continue at the 1980‑2000 levels, upper Columbia River spring-run Chinook salmon populations are projected to have a very high probability of a 90% decline within 50 years (0.87 for the Methow River population, 1.0 for the Wenatchee and Entiat runs). In more recent year (1995–2008) production seems to have increased and, depending upon hatchery effectiveness, has varied between 0.92 and 1.13 (Ford 2011).

Limiting Factors: As noted above, UCR spring-run Chinook salmon inhabit tributaries upstream from the Yakima River to Chief Joseph Dam and the Columbia River mainstem upstream from the Yakima River. Though UCR Chinook are rarely intercepted in ocean fisheries, they face other difficulties including (Upper Columbia Salmon Recovery Board 2007):

- Effects related to hydropower system in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality
- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality
- Degraded estuarine and nearshore marine habitat
- Hatchery-related effects
- Persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species
- Harvest in Columbia River fisheries

Habitat in the area has been degraded by a number of factors, primarily high temperatures, excess sediment, habitat loss, degraded channels, impaired floodplains, and reduced stream flow. All of these factors (and others) have negatively affected the ESU’s PCEs to the extent that it was necessary to list them under the ESA. Additionally, and as noted above, both passage barriers and hatchery effects have had negative impacts on this species, although steps are being taken to improve both those factors through recovery planning.

Status Summary: Several factors—both population- and habitat-related—have caused this ESU to decline to the point that it is likely to become extinct in the foreseeable future. Ford (2011) found all three populations to still be at high risk with regard to their viability. While there has been some improvement in some areas, particularly since the historic lows of the 1990s, the general outlook in terms of all four criteria is that the ESU is still at high risk of becoming extinct and the species is not currently viable (Ford 2011; NMFS 2015f).

4.3.5 Puget Sound Chinook

Description and Geographic Range: On June 28, 2005, NMFS listed Puget Sound (PS) Chinook salmon—both natural and some artificially-propagated fish—as a threatened species (70 FR 37160). The species includes all naturally spawned Chinook salmon populations from rivers and streams flowing into Puget Sound including the Strait of Juan De Fuca from the Elwha River, eastward. This includes rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. Twenty-six artificial propagation programs are part of the species and are also listed (79 FR 20802; April 14, 2014; Table 16).Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural and hatchery PS Chinook salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed (70 FR 37160). NMFS subsequently re-examined the status of this ESU and concluded in 2011 (76 FR 50448) and again in 2016 (81 FR 33468) that the PS Chinook salmon ESU warranted continued listing as threatened.

Table 16. Expected Puget Sound Chinook salmon hatchery releases[14].

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Deschutes	Tumwater Falls	2016	Fall	3,800,000	-
Dungeness-Elwha	Dungeness	2016	Spring	-	50,000
	Elwha	2015	Fall	-	200,000
		2016	Fall	250,000	2,250,000
	Gray Wolf River	2016	Spring	-	50,000
	Hurd Creek	2015	Spring	-	50,000
	Upper Dungeness Pond	2016	Spring	-	50,000
Duwamish	Icy Creek	2015	Fall	300,000	-
	Soos Creek	2016	Fall	3,000,000	200,000
Hood Canal	Hood Canal Schools	2016	Fall	-	500
	Hoodsport	2015	Fall	120,000	-
		2016	Fall	2,800,000	-
Kitsap	Bernie Gobin	2015	Spring	40,000	-
		2016	Fall	-	200,000
			Summer	2,300,000	100,000
	Chambers Creek	2016	Fall	400,000	-
	Garrison	2016	Fall	450,000	-
	George Adams	2016	Fall	3,575,000	225,000
	Gorst Creek	2016	Fall	1,530,000	-
	Grovers Creek	2016	Fall	450,000	-
	Hupp Springs	2016	Spring	-	400,000
	Lummi Sea Ponds	2016	Fall	500,000	-
	Minter Creek	2016	Fall	1,250,000	-
Lake Washington	Friends of ISH	2016	Fall	-	1,425

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
	Issaquah	2016	Fall	2,000,000	-
Nisqually	Clear Creek	2016	Fall	3,300,000	200,000
	Kalama Creek	2016	Fall	600,000	-
Nooksack	Kendall Creek	2016	Spring	800,000	-
	Skookum Creek	2016	Spring	-	1,000,000
Puyallup	Clarks Creek	2016	Fall	400,000	-
	Voights Creek	2016	Fall	1,600,000	-
	White River	2015	Spring	-	55,000
		2016	Spring	-	340,000
San Juan Islands	Friday Harbor ES	2016	Fall	-	225
	Glenwood Springs	2016	Fall	725,000	-
Skykomish	Wallace River	2015	Summer	500,000	-
		2016	Summer	800,000	200,000
Stillaguamish	Brenner	2016	Fall	-	45,000
	Whitehorse Pond	2016	Summer	220,000	-
Strait of Georgia	Samish	2016	Fall	3,800,000	200,000
Upper Skagit	Marblemount	2016	Spring	387,500	200,000
			Summer	200,000	-
Total Annual Release Number				**36,097,500**	**6,017,150**

Adult PS Chinook salmon typically return to freshwater from March through August and spawn from July through December. Early-timed Chinook salmon tend to enter freshwater as immature fish in the spring, migrate far upriver, and finally spawn in the late summer and early autumn. Late-timed Chinook salmon enter freshwater in the fall-run at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry. Most PS Chinook salmon tend to mature at ages three and four, but the range is from two to six years.

Spawning females deposit between 2,000 and 5,500 eggs in a shallow nest, or redd, that they dig with their tail. Depending on water temperatures, the eggs hatch between 32 and 159 days after deposition. Alevins, newly hatched salmon with attached yolk sacs, remain in the gravel for another 14 to 21 days before emerging as fry. Juvenile Chinook salmon may migrate downstream to saltwater within 1 to 10 days and spend many months rearing in the estuary, or they may reside in freshwater for a full year, spending relatively little time in the estuary area, before migrating to sea. Most PS Chinook salmon leave the freshwater environment during their first year. Chinook salmon make extensive use of the protected estuary and nearshore habitats before migrating to the ocean.

Although some PS Chinook salmon spend their entire life in the Puget Sound, most migrate to the ocean and north along the Canadian coast. Return migration routes vary from year to year, with some fish migrating along the west coast of Vancouver Island and others through Johnstone Strait and the Strait of Georgia.

Spatial Structure and Diversity: The PS Chinook salmon ESU contains 31 "historically independent populations," of which nine are believed to be extinct (Ruckelshaus et al. 2006). The extinct populations were mostly composed of early-returning fish from the mid- and southern parts of the Puget Sound and in the Hood Canal/Strait of Juan de Fuca (Table 17).

Table 17. Historical populations of Chinook salmon in the Puget Sound (NMFS 2015f; Ruckelshaus et al. 2006).

Population	MPG	Status	Run Timing
NF Nooksack River	Strait of Georgia	Extant	Early
SF Nooksack River	Strait of Georgia	Extant	Early
Nooksack River late	-	*Extinct*	Late
Lower Skagit River	Whidbey Basin	Extant	Late
Upper Skagit River	Whidbey Basin	Extant	Late
Cascade River	Whidbey Basin	Extant	Early
Lower Sauk River	Whidbey Basin	Extant	Late
Upper Sauk River	Whidbey Basin	Extant	Early
Suiattle River	Whidbey Basin	Extant	Early
NF Stillaguamish River	Whidbey Basin	Extant	Late
SF Stillaguamish River	Whidbey Basin	Extant	Late
Stillaguamish River early	-	*Extinct*	Early
Skykomish River	Whidbey Basin	Extant	Late
Snoqualmie River	Whidbey Basin	Extant	Late
Snohomish River early	-	*Extinct*	Early
Sammamish River	Central and South Puget Sound	Extant	Late
Cedar River	Central and South Puget Sound	Extant	Late
Duwamish/Green River	Central and South Puget Sound	Extant	Late
Duwamish/Green River early	-	*Extinct*	Early
White River	Central and South Puget Sound	Extant	Early
Puyallup River	Central and South Puget Sound	Extant	Late
Puyallup River early	-	*Extinct*	Early
Nisqually	Central and South Puget Sound	Extant	Late
Nisqually River early	-	*Extinct*	Early
Skokomish River	Hood Canal	Extant	Late
Skokomish River early	Hood Canal	*Extinct*	Early
Mid-Hood Canal	Hood Canal	Extant	Late
Mid-Hood Canal early	Hood Canal	*Extinct*	Early
Dungeness River	Strait of Juan de Fuca	Extant	Late
Elwha River	Strait of Juan de Fuca	Extant	Late
Elwha River early	Strait of Juan de Fuca	*Extinct*	Early

Losing these nine historical populations reduced the species' spatial structure. In all cases, the extinct populations overlapped with extant populations, leaving the impression that the spatial structure had not changed. However, the two Chinook salmon run-types tend to spawn in different parts of the watershed (Myers et al. 1998). Early-timed Chinook salmon tend to migrate farther upriver and farther up into tributary streams, whereas, late-timed fish spawn in the mainstem or lower tributaries of the river. Therefore, losing one run timing could cause an underuse of available spawning habitat and reduce population distribution and spatial structure.

Chinook salmon population diversity can range in scale from genetic differences within and among populations to complex life-history traits. The loss of early-run populations is a leading factor affecting ESU diversity. As stated above, eight of the nine extinct populations were composed of early-returning fish (Table 17). Run-timing is a life-history trait considered to be an adaptation to variable environmental conditions. The early-run populations were an evolutionary legacy of the ESU, and the loss of these populations reduces the overall ESU's diversity.

Another major factor affecting PS Chinook salmon diversity is artificial propagation. In 1993, WDF et al. classified nearly half of the ESU populations as sustained, at least in part, by artificial propagation. Since the 1950s, hatcheries have released nearly two billion fish into Puget Sound tributaries. Most of these fish came from fall-run (late returning) adults from the Green River stock or stocks derived from Green River stock resulting in some PS Chinook salmon populations containing substantial hatchery-origin spawner numbers (first generation hatchery fish). By releasing so many hatchery-origin spawners, the use of a single stock could reduce the naturally spawning populations' genetic diversity and fitness. In 1991, a stock transfer policy (WDF 1991) was developed and implemented to foster local brood stocks by significantly reducing egg and juvenile transfers between watersheds. This policy mandates hatchery programs to use local brood stocks in rivers with extant indigenous stocks.

According to recent production estimates, Puget Sound hatcheries release over 40 million juvenile Chinook salmon each year. Most hatchery fish production is for commercial harvest and sport fishing. However, tens of thousands of these fish escape harvest each year and return to spawn in Puget Sound tributaries. From 1990 through 2014, there has been a declining trend in the proportion of natural-origin spawners across the whole ESU (NMFS 2015f). For 2010-2014, more than 70% of the spawners are hatchery fish in eight of the 22 populations (Table 18). For the five major population groups (MPGs) within this ESU, only the Whidbey Basin MPG had over half of their spawners be of natural origin in the majority of the populations (NMFS 2015f).

Table 18. Five-year means of fraction wild for PS Chinook salmon by population (NMFS 2015f).

Population	Five-year means for fraction wild				
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Strait of Georgia MPG					
NF Nooksack River	0.53	0.29	0.07	0.18	0.16
SF Nooksack River	0.76	0.63	0.62	0.63	0.28
Strait of Juan de Fuca MPG					
Elwha River	0.65	0.41	0.54	0.34	0.15
Dungeness River	0.17	0.17	0.16	0.33	0.26
Hood Canal MPG					
Skokomish River	0.52	0.40	0.46	0.45	0.17
Mid-Hood Canal	0.79	0.82	0.79	0.61	0.29
Whidbey Basin MPG					
Skykomish River	0.73	0.46	0.55	0.72	0.73
Snoqualmie River	0.85	0.67	0.87	0.68	0.78
NF Stillaguamish River	0.75	0.65	0.80	0.57	0.59
SF Stillaguamish River	1.00	1.00	1.00	0.99	0.83
Upper Skagit River	0.96	0.98	0.96	0.94	0.96
Lower Skagit River	0.96	0.96	0.97	0.96	0.96
Upper Sauk River	0.96	0.96	0.96	0.96	0.96
Lower Sauk River	0.96	0.96	0.95	0.95	0.96
Suiattle River	0.98	0.98	0.98	0.97	0.98
Cascade River	0.98	0.98	0.98	0.98	0.98
Central / South Sound MPG					
Sammamish River	0.24	0.20	0.40	0.23	0.11
Cedar River	0.74	0.70	0.63	0.82	0.82
Green River	0.44	0.32	0.63	0.44	0.43
Puyallup River	0.84	0.70	0.70	0.40	0.57
White River	0.88	0.93	0.95	0.79	0.56
Nisqually River	0.78	0.80	0.68	0.31	0.30

Abundance and Productivity: Bledsoe et al. (1989) proposed an historical abundance of 690,000 PS Chinook salmon. However, this estimate is based upon the 1908 Puget Sound cannery pack, so it should be viewed cautiously since it probably included fish that originated in adjacent areas. Additionally, exploitation rate estimates used in run-size expansions are not based on precise data.

NMFS concluded in 1998 (Myers et al. 1998), 2005 (Good et al. 2005), 2011 (Ford 2011), and 2015 (NMFS 2015f) that the Puget Sound ESU was likely to become endangered in the foreseeable future. In the first status review, the biological review team (BRT) estimated the total

PS Chinook salmon run size[17] in the early 1990s to be approximately 240,000 Chinook salmon, with the vast majority as hatchery-origin. Based on current estimates, 67,000 of those fish were naturally produced Chinook salmon (Unpublished data, Norma Sands, NWFSC, March 5, 2010). ESU escapement (total spawners) increased to 47,686 (2000-2004), but has since declined to 40,411 (2005-2009) and to 32,451 (2010-2014; Table 19 and Table 20).

Table 19. Abundance–five-year geometric means for adult (age 3+) natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NMFS 2015f).

Population	**Geometric means**					
	1990-1994	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Strait of Georgia MPG						
NF Nooksack River	52 (102)	97 (476)	229 (3,476)	277 (1,675)	154 (1,167)	-44 (-30)
SF Nooksack River	126 (171)	133 (217)	235 (398)	244 (388)	88 (418)	-64 (8)
Strait of Juan de Fuca MPG						
Elwha River	420 (658)	274 (735)	357 (716)	193 (597)	164 (1,152)	-15 (93)
Dungeness River	20 (117)	18 (104)	71 (527)	162 (508)	119 (447)	-27 (-6)
Hood Canal MPG						
Skokomish River	506 (994)	478 (1,232)	479 (1,556)	500 (1,216)	256 (1,627)	-49 (34)
Mid-Hood Canal	93 (119)	152 (186)	169 (217)	47 (88)	75 (314)	60 (257)
Whidbey Basin MPG						
Skykomish River	1,658 (2,325)	1,494 (3,327)	2,606 (4,842)	2,388 (3,350)	1,693 (2,320)	-29 (-31)
Snoqualmie River	873 (1,035)	739 (1,187)	2,161 (2,480)	1,311 (1,965)	885 (1,143)	-32 (-42)
NF Stillaguamish River	553 (742)	603 (946)	967 (1,225)	550 (984)	574 (976)	4 (-1)
SF Stillaguamish River	150 (150)	241 (241)	219 (219)	101 (102)	71 (87)	-30 (-15)
Upper Skagit River	5,389 (5,599)	6,159 (6,267)	12,039 (12,484)	9,975 (10,611)	6,924 (7,194)	-31 (-32)
Lower Skagit River	1,417 (1,473)	1,001 (1,041)	2,765 (2,857)	2,118 (2,216)	1,391 (1,446)	-34 (-35)
Upper Sauk River	394 (409)	258 (268)	413 (428)	498 (518)	836 (867)	68 (67)
Lower Sauk River	399 (414)	414 (433)	812 (853)	546 (572)	413 (432)	-24 (-24)
Suiattle River	295 (302)	373 (382)	405 (415)	254 (261)	351 (360)	38 (38)
Cascade River	185 (189)	208 (213)	364 (371)	334 (341)	338 (345)	1 (1)
Central / South Sound MPG						
Sammamish River	52 (227)	32 (160)	385 (1,040)	289 (1,281)	160 (1,679)	-45 (31)
Cedar River	367 (509)	369 (541)	405 (643)	1,043 (1,275)	881 (1,075)	-16 (-16)
Green River	2,253 (5,331)	2,149 (7,272)	4,099 (6,624)	1,334 (3,187)	897 (2,168)	-33 (-32)

[17] Run size is calculated by combining harvest estimates and spawner estimates.

Population	Geometric means					
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Puyallup River	2,143 (2,543)	1.611 (2,340)	1,171 (1,687)	795 (2,012)	598 (1,186)	-25 (-41)
White River	565 (645)	1,307 (1,415)	3,128 (3,309)	4,170 (5,301)	1,689 (3,471)	-59 (-35)
Nisqually River	630 (806)	596 (748)	891 (1,319)	587 (1,963)	701 (2,577)	19 (31)

In their population viability criteria assessment, the Puget Sound Technical Recovery Team (PSTRT) presented viable spawning abundances for 16 of the 22 populations (Puget Sound Technical Recovery Team 2002) For the 2010 status review (Ford 2011), viable spawning abundances for the remaining six populations were extrapolated based on a recovered productivity equal to the average for the 16 populations (recruits per spawner=3.2). It is important to note that these are viability abundances assume replacement-only productivity–higher productivity would result in lower viable spawning abundances. For this reason, we use the low productivity planning range to evaluate the current abundance trends of PS Chinook salmon (Table 20).

Table 20. Average abundance estimates for PS Chinook salmon natural- and hatchery-origin spawners 2011-2015 (unpublished data, Mindy Rowse, NWFSC, July 17, 2017).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
Strait of Georgia MPG					
NF Nooksack River	154	1,013	86.80%	16,000	93,360
SF Nooksack River	88	330	78.95%	9,100	33,440
Strait of Juan de Fuca MPG					
Elwha River	164	988	85.76%	15,100	92,160
Dungeness River	119	358	75.05%	4,700	38,160
Hood Canal MPG					
Skokomish River	256	1,371	84.27%	12,800	130,160
Mid-Hood Canal	75	239	76.11%	11,000	25,120
Whidbey Basin MPG					
Skykomish River	1,693	627	27.03%	17,000	185,600
Snoqualmie River	885	258	22.57%	17,000	91,440
NF Stillaguamish River	574	402	41.19%	17,000	78,080
SF Stillaguamish River	71	16	18.39%	15,000	6,960
Upper Skagit River	6,924	270	3.75%	17,000	575,520
Lower Skagit River	1,391	55	3.80%	16,000	115,680
Upper Sauk River	836	31	3.58%	3,000	69,360
Lower Sauk River	413	19	4.40%	5,600	34,560

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
Suiattle River	351	9	2.50%	600	28,800
Cascade River	338	7	2.03%	1,200	27,600
Central / South Sound MPG					
Sammamish River	160	1,519	90.47%	10,500	134,320
Cedar River	881	194	18.05%	11,500	86,000
Duwamish/Green River	897	1,271	58.63%	17,000	173,440
Puyallup River	598	588	49.58%	17,000	94,880
White River	1,689	1,782	51.34%	14,200	277,680
Nisqually River	701	1,876	72.80%	13,000	206,160
ESU Average	**19,258**	**13,223**	**40.71%**		**2,598,480**

[a] Five-year geometric mean of post-fishery spawners.
[b] Ford (2011)
[c] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant

The average[18] abundance (2011-2015) for PS Chinook salmon populations is 31,450 adult spawners (18,846 natural-origin and 12,604 hatchery-origin spawners). Natural-origin spawners range from 15 (in the South Fork Stillaguamish River population) to 7,755 fish (in the Upper Skagit population). No populations are meeting minimum viability abundance targets, and only three of 22 populations average greater than 20% of the minimum viability abundance target for natural-origin spawner abundance (all of which are in the Skagit River watershed). The populations closest to planning targets (the Upper Skagit, Cascade, Upper Sauk, and Suiattle) need to increase substantially just to meet the minimum viability abundance target. The Lower Skagit population is the second most abundant population, but its natural-origin spawner abundance is only 10% of the minimum viability abundance target.

Juvenile PS Chinook salmon abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 12,580 females), the ESU is estimated to produce approximately 25.2 million eggs annually. Smolt trap studies have researched egg to migrant juvenile Chinook salmon survival rates in the following Puget Sound tributaries: Skagit River, North Fork Stillaguamish River, South Fork Stillaguamish River, Bear Creek, Cedar River, and Green River (Beamer et al.

18 Average abundance calculations are the geometric mean. The geometric mean of a collection of positive data is defined as the nth root of the product of all the members of the data set, where n is the number of members. Salmonid abundance data tend to be skewed by the presence of outliers (observations considerably higher or lower than most of the data). For skewed data, the geometric mean is a more stable statistic than the arithmetic mean.

2000).[19] The average survival rate in these studies was 10%, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10%, the ESU should produce roughly 2.52 million natural-origin outmigrants annually.

Juvenile listed hatchery PS Chinook salmon abundance estimates come from the annual hatchery production goals. Hatchery production varies annually due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggest that production averages from previous years is not a reliable indication of future production. For these reasons, abundance is assumed to equal production goals. The combined hatchery production goal for listed PS Chinook salmon is 42,114,650 adipose-fin-clipped and non-clipped juvenile Chinook salmon.

Fifteen-year trends in wild spawner abundance were calculated for each PS Chinook salmon population for two time series – 1990-2005 and 1999-2014 (Table 21). Trends were calculated from a linear regression applied to the smoothed wild spawner log abundance estimate (NMFS 2015f). For the 1990-2005 time series, trends were negative for only two of 22 populations. Recent trends (1999-2014), however, were negative for 17 of the 22 populations (NMFS 2015f).

Table 21. Fifteen year trends for PS Chinook salmon for two time series – 1990-2005 and 1999-2014 (NMFS 2015f).

Population	**1990-2005**		**1999-2014**	
	Trend	**95% CI**	**Trend**	**95% CI**
Strait of Georgia MPG				
NF Nooksack River	0.07	(0.04, 0.09)	0.04	(0, 0.07)
SF Nooksack River	0.03	(0, 0.06)	-0.06	(-0.10, -0.02)
Strait of Juan de Fuca MPG				
Elwha River	-0.02	(-0.06, 0.02)	-0.06	(-0.10, -0.03)
Dungeness River	0.14	(0.08, 0.19)	0.09	(0.03, 0.14)
Hood Canal MPG				
Skokomish River	0.02	(-0.01, 0.05)	-0.07	(-0.11, -0.02)
Mid-Hood Canal	0.03	(0, 0.07)	-0.07	(-0.11, -0.02)
Whidbey Basin MPG				
Skykomish River	0.03	(0, 0.06)	-0.02	(-0.04, 0.01)
Snoqualmie River	0.09	(0.05, 0.12)	-0.05	(-0.08, -0.03)
NF Stillaguamish River	0.04	(0.02, 0.06)	-0.04	(-0.06, -0.01)
SF Stillaguamish River	0.01	(-0.01, 0.03)	-0.10	(-0.12, -0.08)
Upper Skagit River	0.07	(0.05, 0.09)	-0.03	(-0.06, 0)
Lower Skagit River	0.05	(0.02, 0.09)	-0.03	(-0.06, -0.01)

19 Data available at WDFW Freshwater Production and Survival of Puget Sound Salmonids (http://wdfw.wa.gov/conservation/research/projects/puget_sound_salmonids/green_river/) and Stillaguamish Tribe Natural Resources Department (http://www.stillaguamish.com/publications.asp), Accessed November 14, 2017.

Population	1990-2005		1999-2014	
	Trend	95% CI	Trend	95% CI
Upper Sauk River	0.01	(-0.02, 0.04)	0.06	(0.04, 0.08)
Lower Sauk River	0.05	(0.01, 0.08)	-0.04	(-0.07, -0.01)
Suiattle River	0.01	(-0.01, 0.03)	-0.01	(-0.04, 0.01)
Cascade River	0.06	(0.04, 0.08)	0.01	(-0.01, 0.03)
Central / South Sound MPG				
Sammamish River	0.17	(0.11, 0.23)	-0.02	(-0.06, 0.02)
Cedar River	0.03	(0, 0.06)	0.07	(0.05, 0.10)
Green River	0.02	(-0.02, 0.06)	-0.12	(-0.16, -0.09)
Puyallup River	-0.03	(-0.05, -0.02)	-0.06	(-0.08, -0.03)
White River	0.19	(0.17, 0.21)	-0.03	(-0.08, 0.01)
Nisqually River	0.05	(0.03, 0.06)	-0.01	(-0.05, 0.03)

Currently, for every natural-origin juvenile that migrates to Puget Sound, 16 listed hatchery juveniles are released into Puget Sound watersheds. The hatchery fish are then targeted for fisheries and removed when they return to their release sites. However, some will stray and others will be missed. For Puget Sound, an average of 40% (range of 2-90%) of the naturally spawning Chinook salmon are first-generation hatchery fish with more than a third of all populations (9 of 22) having more hatchery-origin than natural-origin spawners. Studies have documented that hatchery fish spawning in the wild have a lower success rate than naturally produced fish (Berejikian et al. 2001; Kostow et al. 2003; McLean et al. 2004; Reisenbichler and Rubin 1999).

Limiting Factors: Most of the gains in PS Chinook salmon natural-origin spawner abundance since the 1990s have been lost during the most recent 5-year period (2010-2014) (NMFS 2015f). In fact, 2014 abundance numbers were near the historic lows of the 1990s. In addition, the overall abundance is still only a fraction of historical levels. Several risk factors identified in the 2005 status review (Good et al. 2005) are still present, including high fractions of hatchery fish in many populations and widespread habitat loss and degradation. Additionally, there has been no recent improvement in the species' spatial structure or diversity. None of the extirpated populations has been re-established. However, many habitat and hatchery actions identified in the Puget Sound Chinook salmon recovery plan are expected to take years or decades to be implemented and produce significant improvements (NMFS 2015f). Concerning habitat, the following issues continue to impede PS Chinook salmon recovery throughout the fresh and marine waters of Puget Sound: untreated stormwater, contaminants, shoreline armoring, instream flows, impaired floodplain connectivity, and fish passage.

Status Summary: Across the ESU, most populations have declined in abundance over the past seven to 10 years (NMFS 2015f). Further, all PS Chinook salmon populations are well below the PSTRT planning ranges for recovery escapement levels and below the spawner-recruitment levels identified as consistent with recovery (Ford 2011; NMFS 2015f). Hatchery-origin spawners are present in high fractions in most populations outside of the Skagit River watershed with half of these non-Skagit River watersheds seeing a decrease in the fraction of natural-origin spawners (NMFS 2015f). Overall, most populations have declined in abundance since the last two status reviews in 2005 and 2010; but the biological risk was determined to have not changed since the previous status reviews (NMFS 2015f).

4.3.6 Snake River Fall-run Chinook

Description and Geographic Range: Snake River (SR) fall-run Chinook salmon were first listed as threatened on April 22, 1992 (57 FR 14653). The ESU included all natural-origin populations of fall-run Chinook in the mainstem Snake River and several tributaries including the Tucannon, Grande Ronde, Imnaha, Salmon, and Clearwater Rivers. Fall-run Chinook salmon from the Lyons Ferry Hatchery were included in the ESU but were not listed. When NMFS re-examined the status of this species in 2005, we determined that it still warranted listing as threatened, but in this instance fish from four hatchery programs were considered part of the listed unit (Table 22) (70 FR 37160; June 28, 2005). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish. We are developing a recovery plan for this species.

Table 22. Listed Hatchery Stocks for the SR Fall-run Chinook ESU.

Artificial Propagation Program	Run	Location (State)
Lyons Ferry Hatchery	Fall	Snake River (Idaho)
Fall Chinook Acclimation Ponds Program – Pittsburg, Captain John, and Big Canyon ponds	Fall	Snake River (Idaho)
Nez Perce Tribal Hatchery – including North Lapwai Valley, Lakes Gulch, and Cedar Flat Satellite facilities	Fall	Snake and Clearwater Rivers (Idaho)
Oxbow Hatchery	Fall	Snake River (Oregon, Idaho)

Spatial Structure and Diversity: Adult SR fall-run Chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall-run Chinook salmon generally spawn from October through November, and fry emerge from March through April. Downstream migration generally begins within several weeks of emergence (Allen and Meekin 1973; Becker 1970), and juveniles rear in backwaters and shallow water areas through mid-summer before smolting and migrating to the ocean—thus they exhibit an ocean-type juvenile history. Once in the ocean, they spend one to four years (usually three years) before beginning their spawning migration. Fall-run returns in the Snake River system are typically dominated by 4-year-old fish.

Fall Chinook salmon returns to the Snake River generally declined through the first half of the 20th century. Currently, natural spawning is limited to the area from the upper end of Lower

Granite Reservoir to Hells Canyon Dam; the lower reaches of the Imnaha, Grande Ronde, Clearwater, and Tucannon Rivers; and small mainstem sections in the tailraces of the lower Snake River hydroelectric dams.

The Lyons Ferry Hatchery SR fall-run Chinook salmon broodstock has been used to supply a major natural spawning supplementation effort in recent years (Bugert et al. 1995). Facilities adjacent to major natural spawning areas have been used to acclimate release groups of yearling smolts. Additional releases of subyearlings have been made in the vicinity of the acclimation sites.

Sampling marked returns determine the composition of the fall-run Chinook salmon run at Lower Granite Dam. Since the early 1980s, the run has consisted of three major components: unmarked returns of natural origin, marked returns from the Lyons Ferry Hatchery program, and strays from hatchery programs outside the mainstem Snake River. Although all three components of the fall-run run have increased in recent years, returns of Snake River–origin Chinook salmon have increased at a faster rate than hatchery strays. From the 1990s through the early 2000s, however, hatchery spawners resumed an increasing trend while the natural spawner trend seems to be flattening out (Ford 2011). The apparent leveling off of natural returns in spite of the increases in total brood year spawners was thought to indicate that density dependent habitat effects are influencing production or that high hatchery proportions may be influencing natural production rates. While that may well still be the case, in the last five years, the fraction of natural spawners has continued a slow downward trend on average (Table 23).

Table 23. 5-year mean of fraction natural origin fish in the population (sum of all estimates divided by the number of estimates).

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Snake R. Low. Mainstem	0.62	0.58	0.38	0.37	0.31

Abundance and Productivity: No reliable estimates of historical abundance are available for this ESU. Because of their dependence on mainstem habitat for spawning, however, fall-run Chinook salmon probably have been affected by the development of irrigation and hydroelectric projects to a greater extent than any other species of salmon. It has been estimated that the mean number of adult SR fall-run Chinook salmon declined from 72,000 in the 1930s and 1940s to 29,000 during the 1950s. Despite this decline, the Snake River remained the most important natural production area for fall-run Chinook salmon in the entire Columbia River basin through the 1950s.

Counts of natural-origin adult fish continued to decline through the 1980s, reaching a low of 78 individuals in 1990. Since then, the return of natural-origin fish to Lower Granite Dam has varied, but has generally increased. The largest increase in fall-run Chinook returns to the Snake

River spawning area was from the Lyons Ferry Snake River stock component. Moreover, from the year 2003 through the year 2008, the five-year average return to the ESU was 11,321 adult fish (Ford 2011); of these, approximately 22% were of natural origin. In the following years, those totals continued to increase; from 2009 through 2012, the four-year rolling mean was 34,524 fall-run Chinook returning over Ice Harbor Dam.[20] As Table 24 illustrates, those numbers continued to increase between 2011-2014.

Table 24. 5-year geometric mean of raw natural spawner counts. This is the raw total spawner count times the fraction natural estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown.

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Snake R. Low. Mainstem	333 (581)	548 (980)	3049 (8496)	3662 (10581)	11254 (37812)

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2012-2016 is shown in Table 25 (R. Zabel, NWFSC, unpublished data, 2013-2016).

Table 25. Average Outmigration for SR Fall Chinook Salmon (2012-2016).

Origin	Outmigration*
Natural	544,134
Listed Hatchery Intact Adipose	3,161,673
Listed Hatchery Adipose Clipped	2,812,919

*Listed hatchery outmigration estimates include both yearlings and sub-yearlings; there are no natural-origin yearling fish.

The number of natural fish should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary considerably between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors, however, releases from hatcheries are generally easier to quantify than is natural production.

[20] Data available from University of Washington SAFS Columbia Basin Research at http://www.cbr.washington.edu/, accessed March 2013.

Productivity for this species has varied greatly over the years and is highly dependent upon hatchery effectiveness. The 1990–2001 estimates of the median population growth rate (λ) were 0.98, assuming a hatchery-spawning effectiveness of 1.0 (equivalent to that of wild spawners), and 1.137 with an assumed hatchery-spawning effectiveness of 0.0. The estimated long-term growth rate for SR fall-run Chinook salmon population (1975 – 2008) is generally a positive one. The various rates are 1.06 for total spawners, 1.04 if hatchery effectiveness is zero, and 0.90 if hatchery effectiveness is one (Ford 2011). That slightly positive trend has continued in recent years (NMFS 2015f). However, though the overall trend is positive, concerns remain regarding the increasing hatchery component.

Limiting Factors: SR fall-run Chinook salmon occupy the mainstem Snake River (and the lower reaches of some tributaries) from its confluence with the Columbia River up to the Hells Canyon complex of dams. Almost all historical spawning habitat in the Snake River was blocked by the Hells Canyon Dam complex. Much of the remaining habitat has been reduced by inundation from lower Snake River reservoirs. Spawning and rearing habitats are affected largely by agriculture including water withdrawals, grazing, and riparian vegetation management disruption of migration corridors and affected flow regimes and estuarine habitat. Mainstem Columbia and Snake River hydroelectric development has disrupted migration corridors and affected flow regimes and estuarine habitat. All of these factors, along with harvest, have negatively affected the ESU to the extent that it was necessary to list them under the ESA, therefore we have identified these limiting factors:

- Degradation of floodplain connectivity and function and channel structure and complexity
- Harvest-related effects
- Loss of access to historical habitat above Hells Canyon and other Snake River dams
- Impacts from mainstem Columbia River and Snake River hydropower systems
- Hatchery-related effects
- Degraded estuarine and nearshore habitat.

Status Summary: Several factors—both population- and habitat-related—have caused this ESU to decline to the point that it remains likely to become endangered in the foreseeable future. While there have been some improvement in terms of both abundance and productivity in recent years, it is not enough to prevent them from being listed as a threatened species under the ESA, and they are currently considered to be at moderate risk with regard to the VSP parameters (meaning, the viable salmonid population parameters of spatial structure, diversity, abundance, and productivity) (NMFS 2015f).

4.3.7 Snake River Spring/Summer-Run Chinook

Description and Geographic Range: Snake River (SR) spring/summer-run (spr/sum) Chinook salmon were first listed as threatened on April 22, 1992 (57 FR 14653). At the time, it included all natural-origin populations in the Snake River and the tributaries of the Tucannon, Grande Ronde, Imnaha, and Salmon Rivers. Some or all of the fish returning to several of the hatchery programs were also listed, including those returning to the Tucannon River, Imnaha River, and Grande Ronde River hatcheries, and to the Sawtooth, Pahsimeroi, and McCall hatcheries on the Salmon River. When NMFS re-examined the status of these fish, we determined that they still warranted listing as threatened, but we expanded to 15 the list of hatchery programs contributing fish considered to constitute part of the species (70 FR 37160; June 28, 2005). Subsequently that list was reduced to the 11 programs displayed in Table 26 (79 FR 20802; April 14, 2014). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish. A recovery plan is being developed for this species.

Table 26. List of Hatchery Stocks Included in the SR Spr/sum Chinook Salmon ESU.

Artificial Propagation Program	Run	Location (State)
Tucannon River Program*	Spring	Tucannon River (Washington)
Lostine River (captive*/conventional)	Summer	Grande Ronde (Oregon)
Catherine Creek (captive/conventional)	Summer	Grande Ronde (Oregon)
Lookingglass Hatchery (reintroduction)	Summer	Grande Ronde (Oregon)
Upper Grande Ronde (captive/conventional)	Summer	Grande Ronde (Oregon)
Imnaha River	Spring/ Summer	Imnaha River (Oregon)
Big Sheep Creek	Spring/ Summer	Imnaha River (Oregon)
McCall Hatchery	Summer	South Fork Salmon River (Idaho)
Johnson Creek Artificial Propagation Enhancement*	Summer	East Fork South Fork Salmon River (Idaho)
Pahsimeroi Hatchery	Summer	Salmon River (Idaho)
Sawtooth Hatchery	Spring	Upper Mainstem Salmon River (Idaho)
Dollar Creek**	Spring	SF Salmon River (Idaho)
Panther Creek**	Summer	Salmon River (Idaho)
Yankee Fork**	Spring	Yankee Fork (Idaho)

* Denotes programs that were listed as part of the 1999 listing of the ESU
**Denotes program proposed for inclusion in 2016

Spatial Structure and Diversity: The present range of spawning and rearing habitat for naturally spawned SR spring/summer Chinook salmon is primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon River subbasins. Historically, the Salmon River system may have supported more than 40% of the total return of spring/summer-run Chinook salmon to the Columbia River system (Fulton 1968). Most SR spring/summer Chinook salmon enter individual subbasins from May through September. Juvenile SR spring/summer Chinook salmon emerge from spawning gravels from February through June (Peery and Bjornn, Unpublished data, 1991). Typically, after rearing in their nursery streams for about one year, smolts begin migrating seaward in April and May (Bugert et al. 1990; Cannamela 1992). After reaching the mouth of the Columbia River, spring/summer Chinook salmon probably inhabit nearshore areas before beginning their northeast Pacific Ocean migration, which lasts two to three years.

The South Fork and Middle Fork of the Salmon River currently support the bulk of natural production in the drainage. Two large tributaries entering above the confluence of the Middle Fork Salmon River, the Lemhi and Pahsimeroi Rivers, drain broad alluvial valleys and are believed to have historically supported substantial, relatively productive anadromous fish runs.

SR spring/summer Chinook salmon are produced at a number of artificial production facilities in the Snake River basin. Much of the production was initiated under the Lower Snake River Compensation Plan. Lyons Ferry Hatchery serves as a rearing station for Tucannon River spring-run Chinook salmon broodstock. Rapid River Hatchery and McCall Hatchery provide rearing support for a regionally derived summer-run Chinook salmon broodstock released into lower Salmon River areas. Two major hatchery programs operate in the upper Salmon Basin—the Pahsimeroi and Sawtooth facilities. Since the mid-1990s, small-scale natural stock supplementation studies and captive breeding efforts have been initiated in the Snake River basin.

One threat to diversity from hatchery introgression—the use of the Rapid River Hatchery stock in Grande Ronde drainage hatchery programs—has been phased out since the late 1990s. In addition, a substantial proportion of marked returns of Rapid River Hatchery stock released in the Grande Ronde River have been intercepted and removed at the Lower Granite Dam ladder and at some tributary-level weirs. Carcass survey data indicate large declines in hatchery contributions to natural spawning in areas previously subject to Rapid River Hatchery stock strays.

Abundance and Productivity: No direct estimates of historical SR spr/sum Chinook returns to the Snake River are available. Chapman (1986) estimated that the Columbia River produced 2.5 million to 3.0 million spring and summer Chinook per year in the late 1800s. Total spring and summer Chinook production from the Snake River basin contributed a substantial proportion of those returns; the total annual production of SR spr/sum Chinook may have been in excess of 1.5 million adult returns per year (Matthews and Waples 1991). Returns to Snake River tributaries had dropped to roughly 100,000 adults per year by the late 1960s (Fulton 1968). Increasing hatchery production contributed to subsequent years' returns, masking a continued decline in natural production.

The 1997-2001 geometric mean total return for spring/summer Chinook was slightly more than 6,000 fish. This was a marked improvement over the previous ten years when the geometric mean return was 3,076. That increase continued relatively steadily through 2004, when 97,946 adults returned (including jacks), but dropped off precipitously in 2005 when only 39,126 fish (including jacks) returned above Ice Harbor Dam.[21] The increases from 2001 through 2004 are generally thought to have been a result of good ocean conditions for rearing and good Columbia

[21] Fish Passage Center, Cumulative Adult Passage at Mainstem Dams Through 10/20. Available at http://www.fpc.org, Accessed October 21, 2005.

River flows for outmigration. But even with generally better trends in recent years, no population of spring/summer Chinook is meeting recovery goals. From the year 2008 through the year 2011, the four-year average return to the ESU was 11,819 adult fish (SPS query April 2014); of these, approximately 82% were of natural origin. As

Table 27 demonstrates, those numbers have increased for almost all populations since then.

Table 27. 5-year geometric mean of raw natural origin spawner counts. This is the raw total spawner count times the fraction natural origin estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right.

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Imnaha R. Mainstem SSR	218 (529)	231 (452)	899 (2032)	264 (1196)	699 (2041)	165 (71)
Minam R. SSR	110 (284)	162 (166)	541 (552)	449 (460)	619 (698)	38 (52)
Catherine Cr. SSR	27 (102)	56 (56)	126 (259)	70 (205)	368 (852)	426 (316)
Wenaha R. SSR	71 (305)	164 (186)	612 (638)	354 (364)	488 (643)	38 (77)
Wallowa/Lostine R. SSR	82 (159)	101 (104)	317 (619)	246 (729)	809 (1962)	229 (169)
Grande Rounde R. Up. Mainstem SSR	33 (96)	31 (32)	55 (105)	26 (141)	114 (816)	338 (479)
Tucannon R. SSR	230 (314)	34 (84)	226 (398)	273 (400)	409 (678)	50 (70)
MF Salmon R. Low. Mainstem SSR	N/A	N/A	28 (28)	4 (4)	4 (4)	0 (0)
Camas Cr. SSR	20 (20)	13 (13)	115 (115)	43 (43)	42 (42)	-2 (-2)
Chamberlain Cr. SSR	286 (286)	85 (85)	1107 (1107)	470 (470)	1074 (1074)	129 (129)
Sulphur Cr. SSR	59 (59)	21 (21)	55 (55)	49 (49)	112 (112)	129 (129)
Bear Valley Cr. SSR	177 (177)	95 (95)	662 (662)	319 (319)	776 (776)	143 (143)
MF Salmon R. Up. Mainstem SSR	N/A	13 (13)	140 (140)	52 (52)	104 (104)	100 (100)
Loon Cr. SSR	25 (25)	21 (21)	225 (225)	54 (54)	65 (65)	20 (20)
Big Cr. SSR	76 (76)	29 (29)	302 (302)	121 (121)	270 (270)	123 (123)
Marsh Cr. SSR	102 (102)	99 (99)	285 (286)	126 (126)	564 (564)	348 (348)
EF SF Salmon R. SSR	273 (284)	125 (127)	392 (545)	139 (339)	575 (1041)	314 (207)
SF Salmon R. SSR	690 (1089)	344 (602)	968 (1540)	626 (1124)	923 (1194)	47 (6)
Secesh R. SSR	338 (348)	212 (227)	951 (978)	434 (458)	994 (1014)	129 (121)
Lemhi R. SSR	51 (51)	51 (51)	198 (198)	86 (86)	262 (262)	205 (205)
Salmon R. Up. Mainstem SSR	227 (275)	67 (85)	675 (1104)	327 (564)	624 (897)	91 (59)
Yankee Fork SSR	16 (16)	6 (6)	60 (60)	25 (120)	169 (623)	576 (419)
Valley Cr. SSR	26 (26)	26 (26)	109 (109)	85 (85)	192 (192)	126 (126)
Salmon R. Low. Mainstem SSR	63 (63)	41 (41)	239 (239)	99 (99)	137 (137)	38 (38)
Pahsimeroi R. SSR	N/A	45 (67)	172 (343)	226 (298)	360 (388)	59 (30)
EF Salmon R. SSR	68 (107)	34 (46)	442 (442)	224 (224)	594 (594)	165 (165)

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2012-2016 is shown in Table 28 (R. Zabel, NWFSC, unpublished data, 2013-2016).

Table 28. Average Outmigration for Listed SR spr/sum Chinook Salmon (2012-2016).

Origin	Outmigration
Natural	1,420,448
Listed Hatchery Intact Adipose	1,121,848
Listed Hatchery Adipose Clipped	4,288,088

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Productivity data have been generally lacking since this species was listed. Those data that do exist have been pretty highly variable in terms of methodology, consistency, and coverage. The most recent status review (NMFS 2015f) went to great lengths to compile both the most recent and the historical data for many of the SR spring/summer Chinook populations.

Limiting Factors: This ESU occupies the Snake River Basin—including the headwaters of many streams—from its confluence with the Columbia River, upstream to the Hells Canyon complex of Dams. The area is generally a mix of dry forest, upland steppe, and semi-arid grassland. Streams tend to lose much of their flow through percolation and evaporation, and only the larger rivers that lie below the water table contain substantial flows year round. Extended dry intervals are very common in the Snake River Plateau. Mainstem Columbia and Snake River hydroelectric development has greatly disrupted migration corridors and affected flow regimes and estuarine habitat. There is habitat degradation in many areas related to forest, grazing, and mining practices, with major factors being lack of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads. Therefore all of these factors—along with harvest interceptions and hydropower system mortalities—have negatively affected the ESU to the extent that it was necessary to list it under the ESA:

- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality.

- Effects related to the hydropower system in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality.
- Harvest-related effects.
- Predation.

Status Summary: Several factors—both population- and habitat-related–have caused this ESU to decline to the point that it remains likely to become endangered in the foreseeable future. While there has been some improvement in a number of areas, particularly the 10-year average abundance, it is not enough to prevent them from being listed as a threatened species under the ESA. Ford (2011) rated every population in the ESU (all 28 of them) as being at “high risk” when the four VSP parameters (the viable salmonid population parameters of spatial structure, diversity, abundance, and productivity) were combined into an overall score for each. In general, those ratings were driven by high risk ratings for the abundance and productivity parameters.

4.3.8 Upper Willamette River Chinook

Description and Geographic Range: We listed Upper Willamette River (UWR) Chinook salmon as threatened on March 24, 1999 (64 FR 14308). When we re-examined the status of these fish in 2005, 2011, and 2016, we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). We describe the ESU as all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, Oregon. Also included in the ESU are spring-run Chinook salmon from six artificial propagation programs (79 FR 20802; April 14, 2014).

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (NMFS and ODFW 2011) identifies seven demographically independent populations of spring Chinook salmon: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette. The populations are delineated based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, and environmental and habitat characteristics. The plan identifies the Clackamas, North Santiam, McKenzie, and Middle Fork Willamette populations as “core populations” and the McKenzie as a “genetic legacy population.” Core populations are those that were historically the most productive populations. The McKenzie population is also important for meeting genetic diversity goals. All the populations are part of the same stratum, the Cascades Tributaries Stratum, for the ESU.

Table 29. Historical Population Structure and Viability Status for UWR Chinook Salmon (NMFS and ODFW 2011).

Population	**Population Classification**	**Viability Status**		
		A&P	**Spatial**	**Diversity**
Clackamas	Core population	M	H	M
Molalla	-	VL	L	L
N. Santiam	Core population	VL	L	L
S. Santiam	-	VL	M	M
Calapooia	-	VL	VL	L
McKenzie	Core and Genetic Legacy	VH	M	M
Middle Fork	Core population	VL	L	L

Spatial Structure and Diversity: UWR Chinook salmon exhibit both “ocean type” (i.e., emigration to the ocean as subyearlings) and “stream type” (emigration as yearlings) life histories. Populations tend to mature at ages 4 and 5. Historically, 5-year-old fish dominated the spawning migration runs; recently, however, most fish have matured at age 4. The timing of the spawning migration is limited by Willamette Falls. High flows in the spring allow access to the upper Willamette basin, whereas low flows in the summer and autumn prevent later-migrating fish from ascending the falls. As with UWR steelhead, low flows may serve as an isolating mechanism, separating this species from others nearby. Spring Chinook salmon in the Clackamas River are of uncertain origin, but we consider natural-origin spring Chinook salmon from this subbasin to be part of the listed species. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the listed species. Parr usually undergo a smolt transformation in the spring at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams.

A population’s spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000). For the spatial structure analysis, the Oregon recovery plan evaluated the proportion of stream miles currently accessible to the species relative to the historical miles accessible (NMFS and ODFW 2011). Oregon adjusted the rating downward if portions of the currently accessible habitat were qualitatively determined to be seriously degraded. Oregon also adjusted the rating downward if the portion of historical habitat lost was a key production area. The Oregon recovery plan rates spatial structure to be low to very low in four populations, moderate in two, and high in one. The populations that rate lowest have fish passage barriers, stream channel modifications, and water quality problems limiting distribution of the species.

Willamette Falls, a natural barrier before it was laddered, prevented fall-run Chinook salmon from occupying the upper Willamette River. Thus the UWR Chinook salmon were historically composed of only the spring run. The ladder allows other life history traits to occupy areas in the upper Willamette River; however, none are considered part of the historical populations or the ESU.

The Oregon recovery plan (NMFS and ODFW 2011) rates diversity to be moderate to low in the UWR Chinook ESU (Table 29). Loss of habitat above dams and hatchery production are two factors that have had a negative influence on diversity (Good et al. 2005). As described above, dams and other habitat alterations have reduced or eliminated tributary and mainstem areas. Introduction of fall-run Chinook and laddering the falls have increased the potential for genetic introgression between wild spring and hatchery fall-run Chinook.

Good et al. (2005) identified artificial propagation as a major factor affecting the variation in diversity traits of UWR Chinook salmon. Large numbers of fish from the upper Willamette River (Santiam, McKenzie, and middle fork Willamette rivers) have been introduced since the 1960s. Changes in spawning timing have been observed over the last 100 years. Regardless of origin, the existing spring run has maintained a low to moderate level of natural production (and local adaptation) for a number of generations (McElhany et al. 2004).

Abundance and Productivity: The spring run of Chinook has been counted at Willamette Falls since 1946, but “jacks” (sexually mature males that return to freshwater to spawn after only a few months in the ocean) were not differentiated from the total count until 1952. The average estimated run size from 1946 through 1950 was 43,300 fish, compared to an estimate of only 3,900 in 1994. Even though the number of naturally spawning fish has increased gradually in recent years, many are first generation hatchery fish. Juvenile spring Chinook produced by hatchery programs are released throughout the basin, and adult Chinook returns to the ESU are typically 80-90% hatchery origin fish. In the recovery plan, NMFS and ODFW (2011) found the UWR Chinook ESU to be extremely depressed, likely numbering less than 10,000 fish, with the Clackamas and McKenzie populations accounting for most of the production (Table 30).

Table 30. Estimated Recent Abundance, Viability Goals, and Abundance Targets for Upper Willamette Chinook Populations (NMFS and ODFW 2011)

Population	Wild Abundance (1990-2004)	Viability Goal	Abundance Goal
Clackamas	1,100	Very High	2,046
Molalla	25	High	1,434
N. Santiam	50	High	5,450
S. Santiam	50	High	4,910
Calapooia	25	High	1,225
McKenzie	1,995	Very High	5,486
Middle Fork	50	High	5,870

The Oregon recovery plan (NMFS and ODFW 2011) rates all but two of the populations as very low for abundance and productivity (Table 30). Most populations of the UWR Chinook ESU are far below the recovery goal (Table 30 and Table 31). Abundance in the Clackamas population would need to nearly double, and in the North and South Santiam and Middle Fork populations a 100-fold increase is needed to meet recovery goals.

Recent data on returning adults are summarized in Table 31. Abundance of adult UWR spring Chinook has declined since the highs witnessed around the turn of this century. Over the past five years, natural escapement has ranged from a low of 6,341 to a high of 15,416. The 5-year average return for UWR spring Chinook salmon is 11,443 naturally produced adults and 34,454 hatchery adults (2011-2015).

Table 31. Adult Upper Willamette River Spring Chinook Escapement to the Clackamas River and Willamette Falls Fish Ladder[22]

Year	Total Escapement	Hatchery Escapement	Natural Escapement
2011	51,922	36,506	15,416
2012	43,012	32,334	10,678
2013	35,714	24,332	11,382
2014	37,300	30,959	6,341
2015	61,534	48,137	13,397
Average	**45,896**	**34,454**	**11,443**

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2012-2016 is shown in Table 32 (R. Zabel, NWFSC, unpublished data, 2013-2016).

Table 32. Average Estimated Outmigration for Listed UWR Chinook Salmon (2012-2016).

Origin	Outmigration
Natural	1,287,502
Listed hatchery intact adipose	36,253
Listed hatchery adipose clipped	5,850,595

The number of natural fish should be viewed with caution. Estimating juvenile abundance is complicated by a host of variables: (1) spawner counts and associated sex ratios and fecundity

22 Reports available at http://www.dfw.state.or.us/fish/oscrp/crm/joint_staff_reports_archive.asp, Accessed November 14, 2017.

estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Limiting Factors: The general limiting factors categories for UWR Chinook are habitat access, physical habitat quality/quantity, water quality, competition, disease, food web, population traits, and predation (NMFS and ODFW 2011). The primary threats to UWR Chinook are human impacts, including flood control/hydropower system operations, land use practices (e.g., road building, riparian development, etc.), harvest, hatchery operations, and other species.

Impacts of land management on UWR Chinook include current land use practices causing limiting factors, as well as current practices that are not adequate to address limiting factors caused by past practices (legacy impacts). Past land use (including agricultural, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization) are significant factors now limiting viability of UWR Chinook (NMFS and ODFW 2011). These factors severed access to historically productive habitats, and reduced the quality of many remaining habitat areas by weakening important watershed processes and functions that sustained them. Land use practices in the estuary have degraded or eliminated much of the rearing habitat for UWR Chinook. Combined with the effects of the Columbia River basin hydropower/flood control systems, the primary activities that have contributed to current estuary and lower mainstem habitat conditions include channel confinement (primarily through diking), channel manipulation (primarily dredging), floodplain development, and water withdrawal for urbanization and agriculture (LCFRB 2004).

In the Willamette River mainstem and lower sub-basin mainstem reaches, high-density urban development and widespread agricultural effects have impacted aquatic and riparian habitat quality and complexity, sediment and water quality and quantity, and watershed processes. In upper subbasin mainstem reaches and subordinate tributary streams, the major drivers of current habitat conditions are past and present forest practices, roads, and barriers. Aquatic habitat degradation is primarily the result of past and/or current land use practices that have affected functional attributes of stream channel formation, riparian connectivity, and magnitude and frequency of contact with floodplains, as well as watershed processes. In many subbasins the flood control/hydropower structures in the principal subbasins created new baseline control conditions upon which subsequent habitat alterations have been overlaid.

Harvest impacts from commercial and recreational fisheries on UWR spring Chinook have been substantially reduced in response to extremely low returns in the mid-1990s and subsequent ESA listings in 1999. For spring Chinook, freshwater fishery impacts have been reduced by approximately 75% from 2001 to present compared to the 1980 through the late 1990s (NMFS and ODFW 2011) by implementing selective harvest of hatchery-origin fish in commercial and recreational fisheries, with all unmarked, wild spring Chinook being released. Current exploitation (mortality) of naturally produced Chinook in ocean fisheries averages 11% (1996-2006) and in freshwater fisheries averages 9% (2000-2010) (NMFS and ODFW 2011).

Many UWR Chinook populations are characterized by high proportions of hatchery fish on the spawning grounds (NMFS and ODFW 2011). The vast majority of the UWR Chinook escapement is hatchery fish (Table 31). The major concern with hatcheries is the negative effect hatchery fish spawning in the natural environment have on productivity and long-term fitness of naturally spawning populations.

ODFW identified negative effects of both native and introduced plant and animal species as limiting factors and threats to UWR Chinook (NMFS and ODFW 2011). Ecosystem alterations attributable to hydropower dams and to modification of estuarine habitat have increased predation on UWR Chinook. In the estuary, habitat modification has increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species (Fresh et al. 2005).

Status Summary: The updated information provided in Oregon's recovery plan (NMFS and ODFW 2011) and the information contained in previous UWR Chinook salmon status reviews indicate that most spring-run populations are likely extirpated, or nearly so. The only populations considered potentially self-sustaining are the Clackamas and McKenzie River populations, but abundance is relatively low, with most fish being of hatchery origin. Substantial changes, such as an increase in abundance and a reduction in hatchery influences, are needed before this ESU can recover. Dams, as well as other habitat alterations and hatchery and harvest effects, have affected the listed species. Efforts to make the dams more fish-friendly and to improve river water temperatures should improve the status of the species, but the process has just begun, and more time is needed before we can know the effect of these actions.

4.3.9 Hood Canal Summer-run Chum

Description and Geographic Range: On June 28, 2005, NMFS listed Hood Canal summer-run (HCS) chum salmon—both natural and some artificially-propagated fish—as a threatened species (70 FR 37160). This species was originally listed as threatened on March 25, 1999 (64 FR 14508). The species comprises all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural and hatchery HCS chum salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. Four artificial propagation programs were listed as part of the ESU (79 FR 20802; April 14, 2014; Table 33). NMFS subsequently re-examined the status of this ESU and concluded in 2011

(76 FR 50448) and again in 2016 (81 FR 33468) that the HCS chum salmon ESU warranted continued listing as threatened.

Table 33. Expected Hood Canal summer-run juvenile chum salmon hatchery releases[14].

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Hood Canal	LLTK - Lilliwaup	2015	Summer	-	150,000
Total Annual Release Number					**150,000**

Chum salmon in this ESU are summer-run fish. Juveniles, typically as fry, emerge from the gravel and outmigrate almost immediately to seawater. For their first few weeks, they reside in the top two to three centimeters of estuarine surface waters while staying extremely close to the shoreline (WDFW and PNPTT 2000). Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. HCS chum salmon spawn from mid-September to mid-October (whereas fall-run chum salmon in the same geographic area spawn from November to December or January). Spawning typically occurs in the mainstems and lower river basins. Adults typically mature between the ages of three and five.

Spatial Structure and Diversity: The HCS chum salmon ESU has two populations, each containing multiple stocks or spawning aggregations (Table 34). In the Strait of Juan de Fuca population, state and tribal biologists assessing the species' status in the early 1990s identified small but persistent natural spawning aggregations in three streams (Salmon, Snow, and Jimmycomelately creeks). In the Dungeness River, spawning of unknown aggregations occurred. In Chimacum Creek, HCS chum salmon extirpation occurred in the mid-1980s.

Table 34. Historical populations, spawning aggregations, and the status of summer-run chum salmon in the Hood Canal ESU (Ford 2011; Good et al. 2005; Sands et al. 2009).

Population	Spawning Aggregations	Status	Supplementation/Reintroduction Program
Strait of Juan de Fuca	Dungeness River	Unknown	---
	Jimmycomelately Creek	Extant	Supplementation program began in 1999.
	Salmon Creek	Extant	Supplementation program began in 1992.
	Snow Creek	Extant	---
	Chimacum Creek	*Extinct*	Reintroduction program began in 1996; natural spawning reported starting in 1999.
Hood Canal	Big Quilcene River	Extant	Supplementation program began in 1992.
	Little Quilcene River	Extant	---
	Dosewallips River	Extant	---
	Duckabush River	Extant	---

Population	Spawning Aggregations	Status	Supplementation/Reintroduction Program
	Hamma Hamma River	Extant	Supplementation program began in 1997.
	Lilliwaup Creek	Extant	---
	Big Beef Creek	*Extinct*	Reintroduction program began in 1996; returns reported starting in 2001.
	Anderson Creek	*Extinct*	---
	Dewatto River	*Extinct*	Natural re-colonization occurring, but numbers remain low (<70).
	Tahuya River	*Extinct*	Reintroduction program began in 2000 with increased returns starting in 2006.
	Union River	Extant	---
	Skokomish River	*Extinct*	Spawning documented in recent years.
	Finch Creek	*Extinct*	---

In the Hood Canal population, spawning aggregations persisted in most of the major rivers draining from the Olympic Mountains into the western edge of the Hood Canal, including Big and Little Quilcene Rivers, Dosewallips River, Duckabush River, Hamma Hamma River, and Lilliwaup Creek. On the eastern side of Hood Canal, persistent spawning was restricted to the Union River (Sands et al. 2009). Historical information and habitat characteristics of other streams indicate that summer chum salmon distribution was once more region-wide, especially in the eastern shore streams draining into Hood Canal. Based on river size and historical tribal fishing records, a major spawning aggregation once occurred in the Skokomish River before the construction of Cushman Dam in the 1920s. State and tribal biologists also identified recent extinctions in Big Beef Creek, Anderson Creek, Dewatto River, Tahuya River, and Finch Creek. Historically, additional streams such as Seabeck, Stavis, Big and Little Mission Creeks, and others probably supported summer chum salmon.

In 1992, state and tribal co-managers initiated an extensive rebuilding program for the HCS chum salmon (WDFW and PNPTT 2000; WDFW and PNPTT 2001). Their recovery plan called for five supplementation and three reintroduction projects. After individual projects' production level goals specified in the Summer Chum Salmon Conservation Initiative were met, supplementation or reintroduction programs were terminated on several streams (WDFW and PNPTT 2000; WDFW and PNPTT 2001).

Spatial structure changes are the greatest concern for the ESU’s diversity with HCS chum salmon aggregations being more isolated than they were historically (NMFS 2005). In the past, most HCS chum salmon aggregations were 20-40 km apart with none greater than 80 km. Most extant summer chum salmon aggregations still occur within 20-40 km of each other, but some extinctions have led to a significant increase in spawning aggregations isolated by 80 km or more. Geographically, the extinctions occurred primarily in the northeastern Olympic Peninsula and northwestern Kitsap Peninsula (at the center of the ESU’s geographic range), including all spawning aggregations within the Admiralty Inlet catchment, as well as the Skokomish and Tahuya Rivers. As geographic distances increase between spawning aggregations, they exchange fewer migrants. Such isolations impede the natural exchange of genetic information between spawning aggregations and populations.

Supplementation programs have been very successful in both increasing natural spawning abundance in six of eight extant streams (Salmon, Big Quilcene, Lilliwaup, Hamma Hamma, Jimmycomelately, and Union) and increasing spatial structure due to reintroducing spawning aggregations to three streams (Big Beef, Tahuya, and Chimacum creeks) (NMFS 2015f). The reintroductions have had mixed success, with Chimacum Creek being very successful, but natural-origin production has not yet been sustained in Big Beef Creek and Tahuya River (PNPTT and WDFW 2014). In general, habitat degradation is considered limiting to natural origin production. Habitat preservation and restoration projects in individual watersheds have been implemented concurrently with supplementation programs and have aided in the ability to sustain natural-origin production (NMFS 2015f).

Abundance and Productivity: Historical HCS chum salmon abundance is mostly unknown. Harvest records indicate that chum salmon in the Puget Sound (including the HCS chum salmon ESU) were historically more numerous than Chinook salmon. In 1968, spawning escapement records indicate that 45,000 adult HCS chum salmon returned to tributaries (WDF et al. 1993). During the early 1970s, adult chum salmon spawners dropped to about 20,000 annually (Table 35) (Ford 2011). By the 1980s, HCS chum salmon abundance began to decline ever more precipitously with several spawning aggregations extirpated during this period and with seven spawning aggregations going extinct (Table 35) (Sands et al. 2009). Spawner abundances in both Hood Canal and Strait of Juan de Fuca populations were lowest throughout the 1990s but increased in the early 2000s (NMFS 2015f). Since the late 2000s, abundances have increased by 25% for the Hood Canal population and 53% for the Strait of Juan de Fuca population (Table 35).

Table 35. Abundance–five-year geometric means for adult natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NMFS 2015f).

Population	Geometric means					
	1990-1994	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Hood Canal MPG						
Strait of Juan de Fuca	386 (386)	629 (822)	2,190 (4,178)	4,020 (5,353)	6,169 (8,339)	53 (56)
Hood Canal	979 (979)	5,169 (7,223)	13,145 (18,928)	11,307 (13,605)	14,152 (15,553)	25 (14)

The current average run size of 27,452 adult spawners (25,542 natural-origin and 1,910 hatchery-origin spawners;

Table 36) is largely the result of aggressive reintroduction and supplementation programs throughout the ESU. In the Strait of Juan de Fuca population, the annual natural-origin spawners returns for Jimmycomelately Creek dipped to a single fish in 1999 and again in 2002 (unpublished data, Mindy Rowse, NWFSC, Feb 2, 2017). From 2011 to 2015, Jimmycomelately Creek averaged 2,299 natural-origin spawners. Salmon and Snow Creeks have improved substantially. Natural-origin spawner abundance was 130 fish in 1999, whereas the average for Salmon and Snow creeks were 2,990 and 539, respectively, for the 2011-2015 period.

Table 36. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2011-2015 (unpublished data, Mindy Rowse, NWFSC, Feb 2, 2017).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	2,299	964	29.55%	477,215
Salmon Creek	2,990	2	0.05%	437,468
Snow Creek	539	2	0.36%	79,071
Chimacum Creek	1,273	0	0.00%	186,186
Population Average[d]	7,100	968	12.00%	1,179,941
Hood Canal Population				
Big Quilcene River	7,509	0	0.00%	1,098,212
Little Quilcene River	726	0	0.00%	106,243
Big Beef Creek	68	0	0.00%	9,891
Dosewallips River	2,387	4	0.17%	349,681
Duckabush River	4,137	11	0.25%	606,505
Hamma Hamma River	1,810	7	0.37%	265,681
Anderson Creek	0	0	-	0
Dewatto River	100	0	0.00%	14,574
Lilliwaup Creek	521	510	49.51%	150,780
Tahuya River	207	369	64.10%	84,194
Union River	979	41	3.98%	149,115
Population Average[d]	18,442	942	4.86%	2,834,877
ESU Average	**25,542**	**1,910**	**6.96%**	**4,014,817**

[a] Five-year geometric mean of post fishery natural-origin spawners (2011-2015).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2011-2015).
[c] Expected number of outmigrants=Total spawners*45% proportion of females*2,500 eggs per female*13% survival rate from egg to outmigrant.
[d] Averages are calculated as the geometric mean of the annual totals (2011-2015).

The Hood Canal populations have a similar success story. In 1989, only two summer chum salmon were found in spawning surveys conducted on the Big and Little Quilcene Rivers. Now, they have a combined average of 8,235 natural-origin spawners annually from 2011-2015. Hamma Hamma River returns averaged in the thousands between 1968 and 1979. But by 1989, there were an estimated 16 natural-origin spawners in the Hamma Hamma River. Recent estimates show an average of 1,810 natural-origin HCS chum salmon returning to the Hamma Hamma River annually.

The PSTRT defined interim planning ranges for population level abundance for both high productivity and low productivity (Sands et al. 2009). As the next section illustrates, productivity is low in both populations. Abundance in both populations is currently below the PSTRT planning targets for average natural-origin spawner abundance of 13,000 to 36,000 for the Strait of Juan de Fuca population and 25,000 to 85,000 for the Hood Canal population.

Escapement data, the percentage of females in the population, and fecundity can estimate juvenile HCS chum salmon abundance. ESU fecundity estimates average 2,500 eggs per female, and the proportion of female spawners is approximately 45% of escapement in most populations (WDFW and PNPTT 2000). By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 12,353 females), the ESU is estimated to produce approximately 30.9 million eggs annually. For HCS chum salmon, freshwater mortality rates are high with no more than 13% of the eggs expected to survive to the juvenile migrant stage (Quinn 2005). With an estimated survival rate of 13%, the ESU should produce roughly four million natural outmigrants annually.

Linear regressions of smoothed log natural spawner abundance were applied to both HCS chum salmon populations for two 15-year time series trend analyses (1990-2005 and 1999-2014) (Table 37) (NMFS 2015f). For both time series, trends were positive for both populations (NMFS 2015f)

Table 37. Fifteen year trends for HCS chum salmon for two time series – 1990-2005 and 1999-2014 (NMFS 2015f).

Population	1990-2005		1999-2014	
	Trend	95% CI	Trend	95% CI
Hood Canal MPG				
Strait of Juan de Fuca	0.17	(0.11, 0.23)	0.15	(0.08, 0.21)
Hood Canal	0.22	(0.17, 0.27)	0.07	(0.01, 0.13)

Annual hatchery production goals can estimate juvenile listed hatchery HCS chum salmon abundance. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and availability of adult spawners. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggests that average production from past years is not a reliable indication of production in the coming years. For these reasons, production goals should equal abundance. The combined hatchery production goal for listed HCS chum salmon is 150,000 unmarked juvenile chum salmon.

Limiting Factors and Threats: While there is cause for optimism about this ESU's prospects, there is also cause for continued concern. Supplementation and reintroduction programs have increased natural-origin spawner numbers and distribution in both populations, but these hatchery supplementation programs have mostly ended with only one program continuing. The Hood Canal population has shown improvements since the early 1990s with abundance and productivity gains. With spatial structure, however, there is concern in east Hood Canal where spawning aggregations in Big Beef Creek and Tahuya River are about 60 km apart; thus, to improve spatial structure and ensure spawning aggregations are not isolated, an additional spawning aggregation would be needed in either Dewatto River or Anderson Creek (NMFS 2015f; PNPTT and WDFW 2014). Despite gains in habitat protection and restoration, concerns remain that, given the pressures of population growth, existing land use management measures through local governments (i.e., shoreline management plans, critical area ordinances, and comprehensive plans) may be compromised or not enforced (NMFS 2015f). Overall, limiting factors include degraded estuarine and nearshore habitat, water quality, degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian areas and large woody debris recruitment, degraded stream substrate, and degraded stream flow (NMFS 2016b). Lastly, although abundances have increased for both populations, they are still well below what is targeted by the PSTRT for recovery.

Status Summary: Natural-origin spawner abundance has increased since their 1999 ESA-listing (64 FR 14508; March 25, 1999) and spawning abundance targets in both populations have been met in some years (NMFS 2015f). Productivity was quite low at the time of the last review (Ford 2011), though rates have increased in the last five years, and have been greater than replacement rates in the past two years for both populations. However, productivity of individual spawning aggregates shows only two of eight aggregates have viable performance. Spatial structure and diversity viability parameters for each population have increased and nearly meet the viability criteria. Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (NMFS 2015f).

4.3.10 Columbia River Chum

Description and Geographic Range: Columbia River (CR) chum salmon was first listed as threatened on March 25, 1999 (64 FR 14508). When we re-examined the status of this species in 2005, 2011, and 2016, we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). The ESU includes all naturally-spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon. Two artificial propagation programs are part of the ESU: the Grays River Program and the Washougal River Hatchery/Duncan Creek Program (79 FR 20802; April 14, 2014).

CR chum salmon are fall-run fish. Currently, spawning populations of CR chum salmon are limited to tributaries below Bonneville Dam, with most spawning occurring in two areas on the Washington side of the Columbia River: Grays River, near the mouth of the Columbia River, and Hardy and Hamilton Creeks, approximately three miles below Bonneville Dam. Some chum salmon pass Bonneville Dam, but there are no known extant spawning areas in the Bonneville pool. Juveniles (typically the fry stage) outmigrate to seawater almost immediately after emergence from the gravel and do not have a distinct smolt phase like other salmonids. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. Chum salmon enter the Columbia River from mid-

October through early December and spawn from early November to mid-January. Spawning typically occurs in the mainstem and lower portions of river basins. Adults typically mature as 4-year-olds, although age-3 and age-5 fish are also common (Fulton 1970).

The Willamette/Lower Columbia River Technical Recovery Team (WLC-TRT) partitioned CR chum salmon into three strata based on ecological zones. Ecological zones range from areas at the mouth of the Columbia River that are influenced by the ocean to the Columbia River gorge above Bonneville Dam. The WLC-TRT analysis suggests that a viable ESU would need multiple viable populations in each stratum. The strata and associated populations are identified in Table 38 (Good et al. 2005).

Table 38. Historical Population Structure and Abundance of CR Chum Salmon.

Ecological Zone	Population	EDT estimate of historical abundance*
Coastal	Youngs Bay	ND
	Grays/Chinook	7,511
	Big Creek	ND
	Elochoman/Skamania	ND
	Clatskanine River	ND
	Mill/Abernathy/Germany	ND
	Scappoose Creek	ND
Cascade	Cowlitz River	141,582
	Kalama River	9,953
	Lewis River	89,671
	Salmon Creek	ND
	Clackamas River	ND
	Sandy River	ND
	Washougal River	15,140
Columbia Gorge	Lower gorge tributaries	>3,141
	Upper gorge tributaries	>8,912
TOTAL		**>283,421**

ND = no data
* The EDT estimate of historical abundance is based on analysis by WDFW of equilibrium abundance under historical habitat conditions (McElhany et al. 2003).

Substantial spawning occurs in only two of the 16 historical populations, meaning 88% of the historical populations are extirpated, or nearly so. The two extant populations, Grays River and the lower gorge population, appear to contain only a fraction of the wild historic abundance.

Both populations have benefited from artificial spawning channels constructed to provide habitat that is lacking in the Columbia River.

A large portion of the upper gorge chum population is believed to have been inundated by Bonneville Dam. The WDFW and ODFW conducted surveys to determine the distribution and abundance of chum salmon in the lower Columbia. Very small numbers were observed in several locations in Washington; one chum salmon was observed in Oregon out of 30 sites surveyed (Good et al. 2005).

The leading factor affecting CR chum salmon diversity is the extirpation (or nearly so) of 14 of the 16 historical populations. The remaining populations are at low abundance, although increases in the early 2000s are encouraging. Chum run-timing is rather fixed, compared to other salmon and steelhead, and thus may not help improve the overall diversity of the ESU.

Hatchery programs are established for CR chum, in the Chinook, Grays, and Washougal Rivers, but it is unknown how they have affected natural CR chum salmon. Chum are released at a small size thus are not externally marked before release, though many are otolith marked. The WDFW collected otoliths from spawning chum salmon, but the data will need to be analyzed before any conclusions regarding the hatchery's effects on CR chum salmon diversity can be made. CR chum salmon diversity may not be adversely affected by hatchery releases because the releases have been relatively small and intermittent compared to other stocks in the Columbia River (McElhany et al. 2004).

Abundance and Productivity: Historically, CR chum salmon supported a large commercial fishery that landed more than 500,000 fish per year, and chum salmon were reported in almost every river in the lower Columbia River basin. However, most runs had disappeared by the 1950s. There are now no recreational or directed commercial fisheries for chum salmon in the Columbia River, although chum salmon are taken incidentally in the gill-net fisheries for coho and Chinook salmon, and some tributaries support a minor recreational harvest. The estimated minimum run size for the Columbia River has been relatively stable, although at a very low level, since the run collapsed during the mid-1950s. Current abundance is probably less than 1% of historical levels, and the species has undoubtedly lost some (perhaps most) of its original genetic diversity.

WDFW regularly monitors several natural "index" populations in the basin, in Grays River, two in small streams near Bonneville Dam, and the mainstem area next to those two streams. Average annual natural escapement to the index spawning areas was approximately 1,300 fish from 1990 through 1998. The WDFW surveyed other (nonindex) areas in 1998 and found only small numbers of chum salmon (typically less than 10 fish per stream) in Elochoman, Abernathy, Germany, St. Cloud, and Tanner Creeks and in the North Fork Lewis and the Washougal Rivers. Consistent with the BRT status review (Ford 2011), the ODFW recovery plan concluded that chum are extirpated or nearly so in all Oregon Columbia River populations (ODFW 2010). A few chum are occasionally encountered during surveys or return to hatchery collection facilities, but these are likely either strays from one of the Washington populations or part of a few extremely small and erratic remnant populations. Recent estimates for the lower Columbia Gorge and Grays River chum salmon populations range from 10,000 to 20,000 adults. WDFW spawning surveys in the Grays/Chinook, Washougal, Lower Gorge, and Upper Gorge populations estimated an average of 8,508 adult chum for the years 2007-2011[14]. We do not have recent adult abundance data for any of the other populations.

The Lower Columbia Fish Recovery Board (LCFRB 2010) developed planning ranges for abundance of viable CR chum salmon populations (Table 39). Some abundance goals were not set; the range of abundance is from less than 100 (in the Salmon population) to 6,000 fish (in the Grays/Chinook population). Two of the populations either reach or exceed abundance targets. However, all of the populations are below the planning targets.

Table 39. Recovery Goals and Adult Escapement for CR Chum Salmon Populations (LCFRB 2010)[14].

Population	Viability Goal	Current Viability	Abundance Goal	Adult Escapement		
				Years	Natural	Hatchery
Grays/Chinook	High+	Low+	6,000	2010-2014	6,604	421
Eloch/Skamania	High	Low	1,100	2002-2004	122	
Mill/Aber/Germany	High	V. Low	1,100	2002-2004	40	
Youngs Bay	High	Unknown				
Big Creek	Low	Unknown				
Clatskanie	Med	Unknown				
Scappoose	Low	Unknown				
Cowlitz	Med	V. Low	600			
Kalama	Low	V. Low	150			
Lewis	High	V. Low	1,100	2011-2013	36	
Salmon	V. Low	V. Low	75			
Washougal	High+	Low	5,200	2010-2014	2,440	
Clackamas	Med	Unknown				
Sandy	High	Unknown				
L. Gorge	High+	Med+	2,800	2010-2014	1,600	5
U. Gorge	Med	V. Low	600	2010-2014	106	
Total					**10,644**	**426**
Current abundance numbers are observed 4-year averages or assumed natural spawning escapements.						

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2012-2016 is shown in Table 40 (R. Zabel, NWFSC, unpublished data, 2013-2016).

Table 40. Average Estimated Outmigration for Listed CR Chum Salmon (2012-2016).

Origin	Outmigration
Natural	4,093,920
Listed hatchery intact adipose	662,814

The number of natural fish should be viewed with caution. Estimating juvenile abundance is complicated by several variables: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years and (2) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Trends and growth rate for CR chum salmon are difficult to determine because 14 of the 16 historical populations are extirpated, or nearly so. The two extant populations are at Grays River and the lower Columbia Gorge. The majority of chum salmon spawning in the Grays River currently occurs in less than 1.1 km of the river. Previous to its destruction in a 1998 flood, approximately 50% of the Grays River population spawning occurred in an artificial spawning channel created by the WDFW in 1986. Data from a WDFW analysis conducted in 2000 shows a small upward trend from 1967 to 1998, and a low probability that the population is declining. However, a longer data set indicates that both long- and short-term trends are negative over the period 1950–2000, with a high probability that the trend and growth rate are less than one. Data from the Gorge populations showed a downward trend since the 1950s and a relatively low abundance up to 2000. However, preliminary data indicate that the 2002 abundance showed a substantial increase, estimated to be more than 2,000 chum salmon in Hamilton and Hardy Creeks, plus another 8,000 or more in the mainstem. Overall, due to a limited number of populations and low abundance, CR chum salmon productivity is low (Good et al. 2005).

Limiting Factors and Threats: Chum salmon prefer particular microhabitats for spawning and do not ascend falls or steep gradients like steelhead and other salmon. Overall, fish have been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, and floodplain interactions. These large scale changes have altered habitat conditions and processes important to migratory and resident fish and wildlife (Sands et al. 2009).

Habitat conditions for anadromous fish have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. CR chum salmon are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes in impoundments. For example, a large portion of the upper gorge chum habitat is believed to have been inundated by Bonneville Dam. Chum are affected to a lesser extent than other salmon and steelhead, but dams in many of the larger subbasins have blocked access to large areas of productive habitat (Sands et al. 2009).

Chum salmon were once very abundant in the Columbia River Basin, with commercial landings ranging from 1 to 8 million pounds (80,000 to 650,000 fish) in most years before the early 1940s. Chum escapements have been extremely small since the late 1950s, but improved somewhat recently. The total estimated escapement in 2002 was just under 20,000. NMFS biological opinions now limit the incidental impact of Columbia River fisheries targeting other species to an expected 2% and not to exceed 5% of the annual return of chum listed under the ESA. No sport or commercial fisheries specifically target chum salmon and the current impacts of 3% or less are incidental to fisheries for other species. Numbers incidentally taken in current freshwater or ocean fisheries are not significant. Even though no fisheries target chum salmon, incidental catch in sport and commercial fisheries and illegal harvest can affect the species' VSP criteria (meaning, the four viable salmon population criteria).

4.3.11 Lower Columbia River Coho

Description and Geographic Range: Lower Columbia River (LCR) coho salmon was first listed as threatened on June 28, 2005 (70 FR 37160). When we re-examined the status of these fish in 2011 and 2016, we determined that they still warranted listing as threatened (76 FR 50448; 81 FR 33468). The listing includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia River up to and including the Big White Salmon and Hood Rivers, and including the Willamette River to Willamette Falls, Oregon. Twenty artificial propagation programs are part of the ESU and are also listed (79 FR 20802; April 14, 2014; Table 41).

Table 41. Hatchery Stocks Included in the LCR Coho Salmon ESU.

Artificial Propagation Program	Run	Location (State)
Grays River	Type-S	Grays River (Washington)
Peterson Coho Project	Type-S	Grays River (Washington)
Big Creek Hatchery (ODFW stock # 13)	N/A	Big Creek (Oregon)
Astoria High School (STEP) Coho Program	N/A	Youngs Bay (Oregon)
Warrenton High School (STEP) Coho Program	N/A	Youngs Bay (Oregon)
Cowlitz Type-N Coho Program	Type-N	Upper & Lower Cowlitz River (Washington)
Cowlitz Game and Anglers Coho Program	N/A	Lower Cowlitz River (Washington)
Friends of the Cowlitz Coho Program	N/A	Lower Cowlitz River (Washington)
North Fork Toutle River Hatchery	Type-S	Cowlitz River (Washington)
Kalama River Coho Program	Type-N	Kalama River (Washington)
Kalama River Coho Program	Type-S	Kalama River (Washington)
Lewis River Type-N Coho Program	Type-N	North Fork Lewis River (Washington)

Artificial Propagation Program	Run	Location (State)
Lewis River Type-S Coho Program	Type-S	North Fork Lewis River (Washington)
Fish First Wild Coho Program	N/A	North Fork Lewis River (Washington)
Fish First Type-N Coho Program	Type-N	North Fork Lewis River (Washington)
Syverson Project Type-N Coho Program	Type-N	Salmon River (Washington)
Washougal River Type-N Coho Program	Type-N	Washougal River (Washington
Eagle Creek National Fish Hatchery Program	N/A	Clackamas River (Oregon)
Sandy Hatchery (ODFW stock # 11)	Late	Sandy River (Oregon)
Bonneville/Cascade/Oxbow Complex (ODFW stock # 14)	N/A	Lower Columbia River Gorge (Oregon)

Coho salmon is a widespread species of Pacific salmon, occurring in most major river basins around the Pacific Rim from Monterey Bay, California, north to Point Hope, Alaska, through the Aleutians, and from the Anadyr River south to Korea and northern Hokkaido, Japan. From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in fresh water and 18 months in salt water. Both early-and late-run stocks were present historically and still persist in the lower Columbia River. Type S is an early type that enters the river from mid-August to September, spawns in mid-October to early November, and generally spawns in higher tributaries. Ocean migration for these fish is coastal Washington, Oregon, and Northern California. Type N is a late type that enters the river from late September to December, spawns in November to January, and generally spawns in lower tributaries. Ocean migration for these fish is coastal British Columbia, Washington, and Oregon.

The LCR coho salmon ESU includes 25 populations that historically existed in the Columbia River basin from the Hood River downstream (Table 42). Until recently, Columbia River coho salmon were managed primarily as a hatchery stock. Coho were present in all lower Columbia River tributaries but the run now consists of very few wild fish. Twenty-one of the 24 populations in the ESU are at a very high risk of extinction (Table 42). It is possible that some native coho populations are now extinct, but the presence of naturally spawning hatchery fish makes it difficult to ascertain. The strongest remaining populations occur in Oregon and include the Clackamas River and Scappoose Creek (both at moderate risk of extinction).

Table 42. Historical Population Structure and Viability Status for LCR Coho Salmon (NMFS 2013d).

Stratum	Population	Viability Status		
		A&P	Spatial	Diversity
Coastal	Grays/Chinook	VL	H	VL
	Elochoman/Skamokawa	VL	H	VL
	Mill/Abernathy/Germany	VL	H	L
	Youngs	VL	VH	VL

Stratum	Population	Viability Status		
		A&P	**Spatial**	**Diversity**
	Big Creek	VL	H	L
	Clatskanine	L	VH	M
	Scappoose	M	H	M
Cascade	Lower Cowlitz	VL	M	M
	Upper Cowlitz	VL	M	L
	Cispus	VL	M	L
	Tilton	VL	M	L
	South Fork Toutle	VL	H	M
	North Fork Toutle	VL	M	L
	Coweeman	VL	H	M
	Kalama	VL	H	L
	North Fork Lewis	VL	L	L
	East Fork Lewis	VL	H	M
	Salmon Creek	VL	M	VL
	Washougal	VL	H	L
	Clackamas	M	VH	H
	Sandy	VL	H	M
Gorge	Lower Gorge	VL	M	VL
	White Salmon	VL	M	VL
	Hood	VL	VH	L

Spatial Structure and Diversity: For the spatial structure analysis, the Lower Columbia River recovery plan evaluated the proportion of stream miles currently accessible to the species relative to the historical miles accessible (NMFS 2013d). The recovery plan adjusted the rating downward if portions of the currently accessible habitat were qualitatively determined to be seriously degraded. The recovery plan also adjusted the rating downward if the portion of historical habitat lost was a key production area. The recovery plan rates spatial structure as moderate to very high in nearly all populations of LCR coho. The populations that rate lowest have fish passage barriers. Trap and haul operations on the Cowlitz River pass adults upriver, but downstream passage and survival of juvenile fish is very low. This problem also affects spatial structure in the Cispus and Tilton populations. Merwin Dam blocks access to most of the available spawning habitat in the North Fork Lewis populations. The relicensing agreement for Lewis River hydroelectric projects calls for reintroduction of coho salmon but adequate passage through the system must be achieved to realize the habitat potential. Condit Dam on the White Salmon River blocked access to most of the historical spawning habitat but was removed in 2011. Thus, the LCR coho salmon spatial structure is less diverse than historically, but management actions are underway to improve the situation.

The Lower Columbia River salmon recovery plan (NMFS 2013d) rates diversity to be low to very low in most of the coho populations (Table 42). Pervasive hatchery effects and small population bottlenecks have greatly reduced the diversity of coho salmon populations (NMFS 2013d). Hatchery-origin fish typically comprise a large fraction of the spawners in natural production areas. Widespread inter-basin (but within ESU) stock transfers have homogenized many populations. The Lower Columbia River salmon recovery plan states that there were no observations of coho spawning in lower Columbia River tributaries during the 1980s and 1990s (NMFS 2013d). While historical population structure likely included significant genetic differences among populations in each watershed, we can no longer distinguish genetic differences in natural populations of coho salmon in the lower Columbia River (excluding the Clackamas and Sandy rivers in Oregon).

Abundance and Productivity: Wild coho in the Columbia basin have been in decline for the last 50 years. The number of wild coho returning to the Columbia River historically was at least 600,000 fish (Chapman 1986). At a recent low point in 1996, the total return of wild fish may have been as few as 400 fish. Coinciding with this decline in total abundance has been a reduction in the number of self-sustaining wild populations. Of the 24 historical populations that comprise the LCR coho ESU, only in the case of the Clackamas and Sandy populations is there direct evidence of persistence during the adverse conditions of the 1990s. Since 2000, the numbers of wild coho have increased in both the Clackamas and Sandy basins. During this same period, naturally reproducing coho populations have become re-established in the Scappoose and Clatskanie basins (ODFW 2010).

Table 43 displays the available information on abundance of naturally produced and hatchery LCR coho salmon. Based on the best available data and using a three-year average, the average number of LCR coho salmon spawning in the wild is 32,986 naturally produced fish and 23,082 hatchery produced fish.

Table 43. Estimated Abundance of Adult Lower Columbia River Coho Spawners[13,14].

Stratum	Population	Years	Hatchery	Natural
Coastal	Grays/Chinook	2010-2012	2,155	445
	Elochoman/Skamokawa	2010-2012	1,185	730
	Mill/Abernathy/Germany	2010-2012	51	340
	Youngs	2010-2012	178	119
	Big Creek	2010-2012	136	283
	Clatskanine	2012-2014	250	1,396
	Scappoose	2010-2012	-	823
Cascade	Lower Cowlitz	2010-2012	711	4,834
	Upper Cowlitz/Cispus	2010-2012	9,543	4,015
	Tilton	2010-2012	4,936	1,418
	South Fork Toutle	2010-2012	296	1,357

Stratum	Population	Years	Hatchery	Natural
	North Fork Toutle	2010-2012	467	360
	Coweeman	2010-2012	225	2,976
	Kalama	2010-2012	367	37
	North Fork Lewis	2010-2012	31	533
	East Fork Lewis	2010-2012	365	2,023
	Salmon Creek	2010-2012	426	1,573
	Washougal	2010-2012	253	629
	Clackamas	2012-2014	666	5,151
	Sandy	2012-2014	97	2,591
Gorge	Lower Gorge	2010-2012	269	882
	Upper Gorge/White Salmon	2011-2013	-	104
	Hood	2012-2014	477	367
Total			23,082	32,986

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time, however the average outmigration for the years 2012-2016 is shown in Table 44 (R. Zabel, NWFSC, unpublished data, 2013-2016).

Table 44. Average Estimated Outmigration for Listed LCR Coho Salmon (2012-2016).

Origin	Outmigration
Natural	619,576
Listed hatchery intact adipose	239,784
Listed hatchery adipose clipped	7,514,080

The number of natural fish should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Limiting Factors: The status of LCR coho results from the combined effects of habitat degradation, dam building and operation, fishing, hatchery operations, ecological changes, and natural environmental fluctuations. Habitat for LCR coho has been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, channel alternations, and floodplain interactions. These large-scale changes have altered habitat conditions and processes important to migratory and resident fish and wildlife. Additionally, habitat conditions have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. LCR coho are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes in impoundments. Dams in many of the larger subbasins have blocked anadromous fishes' access to large areas of productive habitat.

Hatchery programs can harm salmonid viability in several ways: hatchery-induced genetic change can reduce fitness of wild fish; hatchery-induced ecological effects—such as increased competition for food and space—can reduce population productivity and abundance; hatchery imposed environmental changes can reduce a population's spatial structure by limiting access to historical habitat; and hatchery-induced disease conveyance can reduce fish health. Practices that introduce native and non-native hatchery fish can increase predation on juvenile life stages. Hatchery practices that affect natural fish production include removal of adults for broodstock, breeding practices, rearing practices, release practices, number of fish released, reduced water quality, and blockage of access to habitat.

The primary fisheries targeting Columbia River hatchery coho salmon occur in West Coast ocean fisheries and Columbia River mainstem fisheries. Most of these fisheries have hatchery-selective harvest regulations or time and area strategies to limit impacts to wild coho. The exploitation rate of coho prior to the 1990s fluctuated from approximately 60% to 90% but now the aggregate annual exploitation rate of wild coho is about 20% or less, while the exploitation of hatchery coho is significantly greater because of mark-selective fisheries. It is unclear whether current exploitation rate limitations for wild coho provide adequate protection for the weak populations included in the aggregate. Wild coho are harvested in Washington, Oregon, California, and Canadian ocean commercial and sport fisheries (about 9% of the total run), and in Columbia River sport, commercial, and treaty Indian fisheries and tributary sport fisheries (about 9% more). Regulations in most fisheries specify the release of all wild (non-fin clipped) coho but some coho are likely retained and others die after release. Fishing-related threats to wild coho salmon escapements include: (1) Ocean and in-river harvest; (2) Release mortalities from hatchery-selective fisheries; and (3) Illegal harvest.

Status Summary: The most serious concern for this ESU is the scarcity of naturally produced spawners and the attendant risks associated with small populations—loss of diversity and fragmentation and isolation among the remaining naturally produced fish. Trap and haul programs have begun to re-introduce coho salmon to many miles of habitat, improving the spatial structure and diversity of the species. Additionally, recent adult returns were up noticeably in some areas, and we have seen evidence for limited natural production in some areas outside the Sandy and Clackamas Rivers. However, more time is needed before we will know if their status will improve.

4.3.12 Lake Ozette Sockeye

Description and Geographic Range: On March 25, 1999, NMFS listed the Ozette Lake (OL) sockeye salmon as a threatened species (64 FR 14528). When we re-examined the status of this species in 2005, 2011, and 2016, we determined that the OZ sockeye salmon ESU still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). The ESU includes all naturally spawned sockeye salmon originating from the Ozette River and Ozette Lake and its tributaries. Also included are sockeye salmon from two artificial propagation programs: the Umbrella Creek Hatchery Program; and the Big River Hatchery Program (79 FR 20802; April 14, 2014). The Umbrella Creek and Big River sockeye hatchery programs (Table 45) were developed in 1982 to augment the beach spawning population and are limited to releases through 2012 (Ford 2011). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 45. Expected Ozette Lake juvenile sockeye salmon hatchery releases[14].

Subbasin	Artificial propagation program	Brood year	Clipped Adipose Fin	Intact Adipose Fin
Hoh-Quillayute	Stony Creek	2015	45,750	137,250
	Umbrella Creek	2015	-	122,000
Total Annual Release Number			**45,750**	**259,250**

Spatial Structure and Diversity: The vast majority of sockeye salmon spawn in lake inlet or outlet streams or in lakes themselves. The offspring of these “lake-type” sockeye salmon use the lake environment for juvenile rearing for one, two, or three years and then migrate to sea. However, some populations of sockeye salmon spawn in rivers without juvenile lake rearing habitat. The offspring of these spawners rear for one or two years in riverine habitats (“river-type” sockeye salmon), or migrate to sea as sub-yearlings after only a few months and therefore rear primarily in saltwater (“sea-type” sockeye salmon) (Gustafson et al. 1997). The duration of time spent in the ocean is the same for all three spawning types—adult sockeye salmon return to the natal spawning habitat after one to four years in the ocean.

Lake Ozette sockeye salmon are lake-type sockeye salmon. Adult sockeye salmon enter Ozette Lake through the Ozette River from April to early August, and hold three to nine months in the lake before spawning in late October through January. Lake Ozette sockeye salmon spawn in lakeshore upwelling areas and in tributaries. Eggs and alevins remain in gravel redds until the fish emerge as fry in spring. Fry then migrate immediately to the limnetic zone where the fish rear. After one year of rearing, Lake Ozette sockeye salmon emigrate seaward as age 1+ smolts in late spring. The majority of Lake Ozette sockeye salmon return to the lake as age 3+ adults and after holding in the lake spawn as four-year-old fish.

Kokanee are populations of *O. nerka* that become resident in the lake environment over long periods of time. Occasionally, a proportion of the juveniles in an anadromous sockeye salmon population will remain in the lake environment their entire lives and will be observed on the spawning grounds together with their anadromous siblings. These resident, non-migratory progeny of anadromous sockeye salmon parents are referred to as “residual sockeye” and “residuals”.

Chamberlain (1907, p. 40) reported that “dwarf sockeye” were present in Ozette Lake around the turn of the century, and it is likely that kokanee were present prehistorically in Ozette Lake. Between 5,000 and 10,000 kokanee spawn in small tributaries to Ozette Lake. Dlugokenski et al. (1981, p. 34) reported that kokanee spawn not only in tributaries, but also spawn interspersed with sockeye salmon on the lakeshore in mid-November to early December.

The OL sockeye salmon ESU is composed of one historical population, with substantial substructuring of individuals into multiple spawning aggregations. The primary existing spawning aggregations occur in two beach locations on Ozette Lake, Allen’s and Olsen’s beaches, and in two tributaries, Umbrella Creek and Big River (both tributary-spawning groups were initiated through a hatchery introduction program). In addition, mature adults have been located at other beach locations within the lake (e.g., Umbrella Beach, Ericson’s Bay, Baby Island, and Boot Bay); but whether spawning occurred in those locations is not known (Good et al. 2005). Similarly, occasional spawners are found sporadically in other tributaries to the lake, but not in as high numbers or as consistently as in Umbrella Creek.

The Umbrella Creek spawning aggregation was started through collections of lake-spawning adults as initial broodstock, and in recent years all broodstock has been collected from returning adults to Umbrella Creek (Good et al. 2005). There is some disagreement as to the extent to which sockeye salmon spawned historically in tributaries to the lake (Gustafson et al. 1997), but it is clear that multiple beach-spawning aggregations of sockeye salmon occurred historically and that genetically distinct kokanee currently spawn in large numbers in all surveyed lake tributaries (except Umbrella Creek and Big River). The two remaining beach-spawning aggregations are probably fewer than the number of aggregations that occurred historically, but it is unknown how many subpopulations occurred in the ESU historically.

Diversity is the variety of life histories, sizes, and other characteristics expressed by individuals within a population. As stated previously, the OL sockeye salmon ESU once had two life history patterns: tributary spawners and beach spawners. Although there are numerous anecdotal accounts of historical tributary spawning, a series of intense basin-wide surveys in the late 1970s and early 1980s found only beach spawners. The loss of tributary spawning aggregations represents a loss of an important life history type that may have been genetically distinct from beach spawning aggregations. Depleted run-sizes and the loss of tributary spawning aggregations prompted managers to initiate a re-introduction and supplementation program in three of the Ozette Lake tributaries (e.g. Umbrella Creek, Big River, and Crooked Creek).

With the first broodstock collection in 1983, the Umbrella Creek spawning aggregation was established using a combination of brood stock collected at Olsen's and Allen's Beaches (NMFS 2009b). After OL sockeye were listed in 1999, the hatchery program has been managed to protect the genetic diversity of beach spawning aggregations. Since 2000, broodstock collection has been restricted to natural origin tributary spawners, and juvenile sockeye from the program have been outplanted in Umbrella Creek and Big River. Observations of sockeye spawning in Big River during the winter of 1998 before any hatchery out-planting suggests that sockeye strayed into new habitats, potentially in an attempt to colonize new environments. The expected duration of the tributary hatchery programs is 12 years, or three sockeye salmon generations, per release site. These programs should improve the ESU's diversity by extending the range of spatial distribution, which may, in turn, contribute to life history diversity and increase the resiliency of the population (Good et al. 2005).

Based upon variation in peak spawn timing and genetic differences observed in tissue samples experts have argued that the beach spawning aggregations may be separate populations (Haggerty et al. 2009). However, Hawkins (2004) found that there was very little genetic structure among the sockeye spawning aggregations at Olsen's Beach, Allen's Beach, and Umbrella Creek. Hawkins (2004) found cohort lineages along the predominant 4-year brood cycle to be closely related independent of sampling locations.

Sockeye and kokanee salmon are known to interact during the fresh-water rearing phase of the sockeye salmon, which coincides with nearly the entire life history phase of kokanee. Genetic evidence analyzed by Hawkins (2004) indicates that hybridization between sockeye and kokanee salmon appears to have been occurring before 1991 and continues to be persistent between the two populations. However, the genetic mixing between sockeye salmon and kokanee is of low enough frequency to maintain the large genetic differences observed between the two populations (Hawkins 2004).

Abundance and Productivity: Historical abundance of OL sockeye salmon has been estimated from weir counts and harvest records. The earliest attempt to quantify the size of the OL sockeye salmon run occurred in 1924-1926 when the U.S. Fish and Wildlife Service (FWS) installed and operated a counting weir downstream from the lake's outlet in the Ozette River (Haggerty et al. 2009). However, the weir deployment missed the early part of the run; and weir counts did not account for the number of sockeye salmon harvested. Between 1948 and 1976, the Washington Department of Fisheries collected harvest data; but no escapement data was collected for those years. Estimates made from these data sets indicate a maximum escapement of a few thousand sockeye salmon in 1926 and a peak harvest of more than 17,000 in 1949 (Gustafson et al. 1997).

However, in some years the total run size may have been more than 1949's peak-recorded harvest. Blum (1988) speculated that before the 1940s, the OL sockeye salmon run-size exceeded 50,000 fish.

After the Makah Tribe's annual OL sockeye salmon harvest peaked at 17,000 in 1949 (WDF 1955), harvest declined sharply thereafter and ceased altogether in 1974. In an effort to protect and increase the spawning sockeye salmon abundance, all ceremonial and subsistence tribal fishing ended in 1982. Despite the cessation of harvest, OL sockeye salmon runs never rebounded.

In 1977, the FWS, USGS, and the Makah Tribe installed a counting weir in the Ozette River, near the lake's outlet. The methods used to enumerate and estimate Lake Ozette sockeye run sizes changed several times between 1977 and the present. Methods ranged from nighttime weir counts (1977-1981), 24-hour counts (1982, 1984, 1986), and visual – hour counts with an underwater video camera (1998-2003). In 1998, the operation period was expanded to include earlier starting and later ending dates. The changes in 1998 allowed for a more complete count of all fish passing the weir. It is likely that counts for previous years underestimated total spawner abundance, but the magnitude of this bias is unknown. Since 2004, survey data appears to be scantly and of poor quality with the Makah Tribe not making any total spawning estimates for these years. Beginning in 2011, dual frequency identification sonar (ARIS) surveys began along the main spawning beaches in Lake Ozette (Haggerty and Makah Fisheries Management 2013). Due to predation problems at the Ozette River weir and poor visibility at the spawning beaches, the ARIS surveys were chosen to count OL sockeye; and after a few years of data calibration, the goal is to remove the weir from the Ozette River (NMFS 2016a). From 2012 onward, all abundance data is preliminary and has not been published. From 2007 through 2011, the current average run size is 2,321 adult spawners (2,143 natural-origin and 178 hatchery origin spawners; Table 46) for the ESU.

Table 46. Five-year geometric means (2007-2011) for adult natural-origin and hatchery-origin spawners for the OL sockeye salmon ESU (NMFS 2015f).

Year	Ozette Lake[a]		Umbrella Creek		Total	
	Natural-origin Spawners	Hatchery-origin Spawners	Natural-origin Spawners	Hatchery-origin Spawners	Natural-origin Spawners	Hatchery-origin Spawners
2007	692	0	42	7	734	7
2008	443	44	1,430	234	1,873	278
2009	1,031	127	3,037	574	4,068	701
2010	791	51	3,056	270	3,847	321
2011	1,597	120	503	237	2,100	357
ESU Average					**2,143**	**178**

[a] Ozette Lake spawners include all OL sockeye salmon except for those counted at the Umbrella Creek weir.

Juvenile OL sockeye abundance can be estimated from escapement data. Fecundity estimates for the ESU average 3,050 eggs per female (Haggerty et al. 2009), and the proportion of female spawners is assumed to be 50% of escapement. By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 1,161 females), the ESU is estimated to produce approximately 3.54 million eggs annually. Analyzing data from 1991 to 2007 for the Lake Washington sub-basin, McPherson and Woodey (2009) found an average egg-to-fry survival rate of 13.5% (range 1.9-32.0%). Assuming a similar 13.5% egg-to-fry survival for Lake Ozette, the ESU should produce roughly 477,836 natural outmigrants annually.

Spawning habitat capacity estimates for beach and tributary habitats (combined) range from 90,000 to 120,000 adult OL sockeye salmon (NMFS 2009b). These estimates are based upon a relatively low spawning density target of one female per three sq. meters of suitable habitat. However, historical spawning density may have been as high as one female/sq. meter, which would triple the capacity estimates. Nonetheless, the most recent five-year average for natural origin adult sockeye escapement is only 2.4% of the lower estimate (2,143/90,000).

Listed hatchery sockeye abundance can be estimated from the annual hatchery production goals. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. The uncertainty in funding and the inability to predict equipment failures, human error, and disease suggests that an average production from past years is not a reliable indication of production in the coming years. For these reasons, abundance is assumed to be equal to the production goals. The combined hatchery production goal for listed OL sockeye is 305,000 juvenile sockeye salmon (Table 46).

Limiting Factors: The limiting factors continue to be loss of adequate and quantity of spawning and rearing habitat, predation and disruption of natural predator-prey relationships, and introduction of non-native fish and plant species (Good et al. 2005). Significant habitat concerns, particularly regarding spawning beach conditions, include hydrologic patterns that are legacy effects of streamside timber practices and large wood removal, which will take decades to ameliorate without affirmative restoration activities (NMFS 2016a). The low productivity of the beach spawning aggregation(s) is a continuing concern that will require corrective habitat measures on the part of the co-managers and the Olympic National Park in order for viability benefits to accrue. Further, the current operation and management of the weir at Ozette Lake currently constrains sockeye migration and delays both upstream and downstream fish passage, which results in increased fish and mammal predation by northern pikeminnow, harbor seal, and river otter on migrating juvenile and/or adult sockeye as they encounter the weir. Also, climate change also portends increasing frequency of detrimental conditions similar to those experienced throughout 2015 (NMFS 2016a).

Status Summary: Abundance of Lake Ozette sockeye salmon has not changed substantially from the last status review (NMFS 2015f). The quality of data continues to hamper efforts to assess more recent trends and spatial structure and diversity although this situation is improving (NMFS 2015f). Overall, the biological risk was determined to have not changed between the 2005, 2010, and 2015 status reviews—that the Lake Ozette sockeye salmon ESU remains listed as a threatened species as the species is likely to become endangered in the foreseeable future (Ford 2011; NMFS 2015f).

4.3.13 Snake River Sockeye

Description and Geographic Range: The Snake River (SR) sockeye salmon ESU was listed as endangered on November 20, 1991 (56 FR 58619). When we re-examined the status of this species in 2005, 2011, and 2016, we determined that the SR sockeye salmon ESU still warranted listing as endangered (70 FR 37160; 76 FR 50448; 81 FR 33468). The SR sockeye salmon ESU includes all naturally spawned anadromous and residual populations of sockeye salmon from the Snake River Basin, Idaho (extant populations occur only in the Salmon River subbasin). SR sockeye salmon produced in the Idaho Department of Fish and Game's (IDFG's) captive broodstock program are also included in the Listed ESU. There is a recovery plan for this species (NMFS 2015b).

Spatial Structure and Diversity: Sockeye salmon adults enter the Columbia River primarily during June and July. Arrival of natural-origin adults at the Redfish Lake Creek trap and broodstock-origin adults at the trap and the Sawtooth Hatchery weir peaks in August. Natural spawning occurs only in Redfish Lake and primarily in October (Bjornn et al. 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks, emerge from April through May, and move immediately into the lake. Once there, juveniles feed on plankton for one to three years before they migrate to the ocean (Bell 1986). Migrants leave Redfish Lake during late April through May (Bjornn et al. 1968) and travel almost 900 miles to the Pacific Ocean. Smolts reaching the ocean remain inshore or within the influence of the Columbia River plume during the early summer months. Later, they migrate through the northeast Pacific Ocean (Hart 1973; Hartt and Dell 1986). Sockeye salmon spend two to three years in the Pacific Ocean and return in their fourth or fifth year of life.

Four adult sockeye salmon returned to Redfish Lake in 1991; they were taken into captivity to join several hundred smolts collected in spring 1991 as they outmigrated from Redfish Lake. The adults were spawned and their progeny reared to adulthood along with the outmigrants as part of a captive broodstock program, whose major goal was to perpetuate the gene pool for a short period of time (one or two generations) to give managers a chance to identify and address the most pressing threats to the population. Genetic data collected from the returning adults and the outmigrants showed that they were genetically similar but distinct from the Fishhook Creek kokanee. However, otolith microchemistry data indicated that many of the outmigrants did have a resident female parent. These results inspired a search of Redfish Lake for another population of resident fish that was genetically similar to the sockeye. These efforts led to discovery of a relatively small number (perhaps a few hundred) kokanee-sized fish that spawn at approximately the same time and place as the sockeye. These fish, termed residual sockeye salmon, are considered to be part of the listed ESU. Subsequent genetic analysis (Waples et al. 1991) established the following relationships between extant populations of *O. nerka* from the Stanley Basin and other populations in the Pacific Northwest:

At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural production (NMFS 2015d). Initial releases of adult returns directly into Redfish Lake have been observed spawning in multiple locations along the lake shore as well as in Fishhook Creek (NMFS 2015d). There is some evidence of very low levels of early timed returns in some recent years from outmigrating naturally produced Alturas Lake smolts. At this stage of the recovery efforts, the ESU remains rated at High Risk for both spatial structure and diversity.

Although total sockeye salmon returns to the Sawtooth Basin in recent years have been high enough to allow for some level of spawning in Redfish Lake, the hatchery program remains in its initial phase with a priority on genetic conservation and building sufficient returns to support sustained outplanting (NMFS 2015d; NMFS 2015f).

Abundance and Productivity: Given the dire status of the species under any criteria (a recent peak of 150 natural and 950 hatchery adult sockeye returned to the Stanley Basin in 2011), NMFS considers the captive broodstock and its progeny essential for recovery. Between 1997 and 2005, approximately 400 hatchery sockeye returned to the Stanley Basin, total. Only 16 naturally produced adults returned to Redfish Lake between the time the Snake River sockeye ESU was listed as an endangered species in 1991 and 2005. Since that time, there has been a considerable improvement in the sockeye returns. From 2009 through 2012, an average of 1,348 adult sockeye (all from the broodstock program) passed Lower Granite Dam on their way to Redfish Lake. The year 2012 saw the lowest numbers of that period—with only 470 fish being counted at Lower Granite Dam. These numbers have been updated somewhat with the 2014 returns—which numbered 2,786 fish. The new four-year average return to Lower Granite Dam (through 2014) is 1,373. The average number of returning adults to the Stanley Basin from 2010 to 2014 was 916 (NMFS 2015f). Unfortunately, though, 2015 was a very bad year in which only a few dozen sockeye returned to the basin. The reason was high water temperatures along their migration route.

Each spring, the NWFSC produces a memorandum estimating the number of listed Pacific salmon and steelhead smolts expected to arrive at various locations in the Columbia River basin. The averages of the five most recent projections for the SR sockeye salmon juvenile emigrants are displayed in Table 47.

Table 47. Recent Five-Year Average Projected Outmigrations for SR Sockeye (R. Zabel, NWFSC, unpublished data, 2013-2016).

Origin	Outmigration
Natural	18,300
Listed Hatchery: Adipose Clipped*	173,648
*When the above species was listed, NMFS included fish from a captive broodstock program. Those listed fish have had their adipose fins clipped.	

The Biological Review Team (BRT), reviewing the status of the species in 2010 (Ford 2011), found that the recent increase in returns of hatchery-reared Snake River sockeye has reduced the risk of immediate loss, but that levels of naturally produced returns remain extremely low. Although the biological risk status of the ESU appeared to be on an improving trend, the new information did not indicate a change in category (extremely high risk) since the 2005 BRT status review. That assessment remained unchanged in the 2015 review.

The only real source of productivity for this ESU is the Redfish Lake Captive Broodstock Program. Unfortunately, the BRT's assessment of the effects of artificial propagation on ESU extinction risk concluded that the Redfish Lake Captive Broodstock Program does not substantially reduce the extinction risk of the ESU in-total (70 FR 37160, 37179). Nonetheless, the Artificial Propagation Evaluation Workshop noted that the Captive Broodstock Program has *prevented* likely extinction of the ESU. This program has increased the total number of anadromous adults, increased the number of lakes in which sockeye salmon are present in the upper Salmon River (Sawtooth Valley), and preserved what genetic diversity remained in the ESU at the time the population went through a bottleneck (circa 1990). The majority of the ESU resides in the captive program composed of only a few hundred fish. The long-term effects of captive rearing are unknown. The consideration of artificial propagation does not substantially mitigate the BRT's assessment of extreme risks to ESU abundance, productivity, spatial structure, and diversity.

Limiting Factors and Threats: SR sockeye travel further inland—approximately 900 miles—than any other Pacific salmon. They pass through mainstem Snake and Salmon Rivers, the South Fork Salmon River, and move up to the Stanley Basin to their one remaining spawning ground in Redfish Lake, Idaho. The area is generally a mix of dry forest, upland steppe, and semi-arid grassland. The key factor limiting recovery of SR sockeye salmon ESU is survival outside of the Stanley Basin. Portions of the migration corridor in the Salmon River are impaired by reduced water quality and elevated temperatures (Ford 2011). The natural hydrological regime in the upper mainstem Salmon River Basin has been altered by water withdrawals. Survival rates from Lower Granite dam to the spawning grounds are low in some years (e.g., average of 31%, range of 0-67% for 1991-1999) (Keefer et al. 2008). Keefer et al. (2008) conducted a radio tagging study on adult SR sockeye salmon passing upstream from Lower Granite Dam in 2000 and concluded that high in-river mortalities could be explained by "a combination of high migration corridor water temperatures and poor initial fish condition or parasite loads." Keefer et al. (2008) also examined current run timing of SR sockeye salmon versus records from the early 1960s, and concluded that an apparent shift to earlier run timing recently may reflect increased mortalities for later migrating adults. In the Columbia and lower Snake River migration corridor, predation rates on juvenile sockeye salmon are unknown, but terns and cormorants consume 12% of all salmon smolts reaching the estuary, and piscivorous fish consume an estimated 8% of migrating juvenile salmon (Ford 2011).

Status Summary: Ford (2011) concluded that the Snake River sockeye ESU continues to be "in danger of extinction." The ESU's status is such that there must be substantial increases in its abundance, productivity, and diversity and the species must be successfully reintroduced in more of its historical range if it is to survive. The increased abundance of hatchery reared Snake River sockeye reduces the risk of immediate loss, but levels of naturally produced sockeye returns remain extremely low. As a result, and again despite recent improvements in adult returns, Ford (2011) determined that the species is still substantially at risk with regard to all VSP parameters (spatial structure, diversity, abundance, and productivity).

5. ENVIRONMENTAL BASELINE

The "Environmental Baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impacts of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this opinion includes the effects of several activities that affect the survival and recovery of ESA-listed resources in the action area.

A number of human activities have contributed to the current status of populations of ESA-listed species in the action area. The factors that have likely had the greatest impact are discussed in the sections below. For more information on all factors affecting the ESA-listed species considered in depth in this opinion, please refer to the following documents for each listed species:

- listing documents (Table 7)
- recovery plans (available at http://www.nmfs.noaa.gov/pr/recovery/plans.htm)
- status reviews (available at http://www.nmfs.noaa.gov/pr/listing/reviews.htm)
- marine mammal stock assessment reports (available at http://www.nmfs.noaa.gov/pr/sars/)

The following information summarizes the principal natural and human-caused phenomena in the action area believed to affect the survival and recovery of ESA-listed species under NMFS jurisdiction in the wild. Summaries of how individual species are affected by threats are provided in the Status of Species section and in the documents listed above.

5.1 Climate and Environmental Change

Since the 1950s the atmosphere and oceans have warmed, snow and sea ice have diminished, sea levels have risen, and concentrations of greenhouse gases have increased (IPCC 2013). While both natural and anthropogenic factors have influenced this warming, human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC 2013). In marine ecosystems, shifts in temperature, ocean circulation, stratification, nutrient input, oxygen content, and ocean acidification are associated with climate change and increased atmospheric carbon dioxide (Doney et al. 2012), and these shifts have potentially far-reaching biological effects. The impacts of climate change are especially pronounced at high latitudes and in polar regions.

Average temperatures have increased across Alaska at more than twice the rate of the rest of the United States.[23] In the past 60 years, average air temperatures across Alaska have increased by approximately 3˚F, and winter temperatures have increased by 6˚F (Chapin et al. 2014). In the Chukchi Sea, August sea surface temperatures are warming more than 4.5 times faster than other

23 United States Environmental Protection Agency, https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-alaska_.html, Accessed December 5, 2017.

oceans, at a rate of 1.3˚F per decade since the 1980s.[24] In August 2017, sea surface temperatures in the Barents and Chukchi seas were up to 7.2˚F warmer than the 1982-2010 average August temperatures. Some of the most pronounced effects of climate change in Alaska include disappearing sea ice, shrinking glaciers, thawing permafrost, and changing ocean temperatures and chemistry (Chapin et al. 2014).

Arctic summer sea ice is receding faster than previously projected and is expected to virtually disappear before mid-century (Chapin et al. 2014). In fact, the NOAA 2017 Arctic Report Card states that the Arctic "shows no sign of returning to the reliably frozen region of recent past decades." While a changing climate may create opportunities for range expansion for some wide-ranging generalist species such as gray whales, the life cycles and physiological requirements of many specialized polar species are closely linked to the annual cycles of sea ice and photoperiod (Doney et al. 2012). Thus, the loss of sea ice may alter marine ecosystems and reduce habitat for ice-associated species such as listed bearded seals and polar bears in ways to which they cannot adapt at the rate the changes are occurring. Additionally, the loss of sea ice increases the potential for further anthropogenic impacts as vessel traffic for transportation and tourism and resource extraction activities move into newly ice-free regions.

Increasing ocean temperature, decreasing seasonal ice cover and extent, and increasing freshwater content in Alaska's oceans are changing ocean currents and stratification, nutrient cycles, upwelling, food webs, species composition, primary and secondary productivity, species distributions, and predator-prey interactions (Doney et al. 2012). The impacts of these changes and their interactions on listed species in Alaska are hard to predict. A recent period of especially warm water in the North Pacific Ocean, referred to as "the blob," is likely responsible for poor growth and survival of Pacific cod, an important prey species for endangered Steller sea lions. The preliminary 2017 estimate of Pacific cod biomass is approximately 28% of the average biomass since 1984. Biologists also attribute increases in bird die-offs, whale strandings, toxic algae blooms, and poor salmon survival to warmer water conditions.[25]

For 650,000 years or more, the average global atmospheric carbon dioxide concentration varied between 180 and 300 parts per million (ppm), but since the beginning of the industrial revolution in the late 1700s, atmospheric CO_2 concentrations have been increasing rapidly, primarily due to anthropogenic inputs (Fabry et al. 2008). The world's oceans have absorbed approximately one-third of the anthropogenic CO_2 released, which has curtailed the increase in atmospheric CO_2 concentrations (Sabine et al. 2004). Despite the oceans' role as large carbon sinks, in 2016, the mean monthly average atmospheric CO_2 level exceeded 400 ppm and continues to rise (Figure 23).

24 NOAA. http://www.arctic.noaa.gov/Report-Card/Report-Card-2017, Accessed December 14, 2017.
25 "Climate change preview? Pacific Ocean 'blob' appears to take toll on Alaska cod," *Seattle Times*, November 4, 2017.

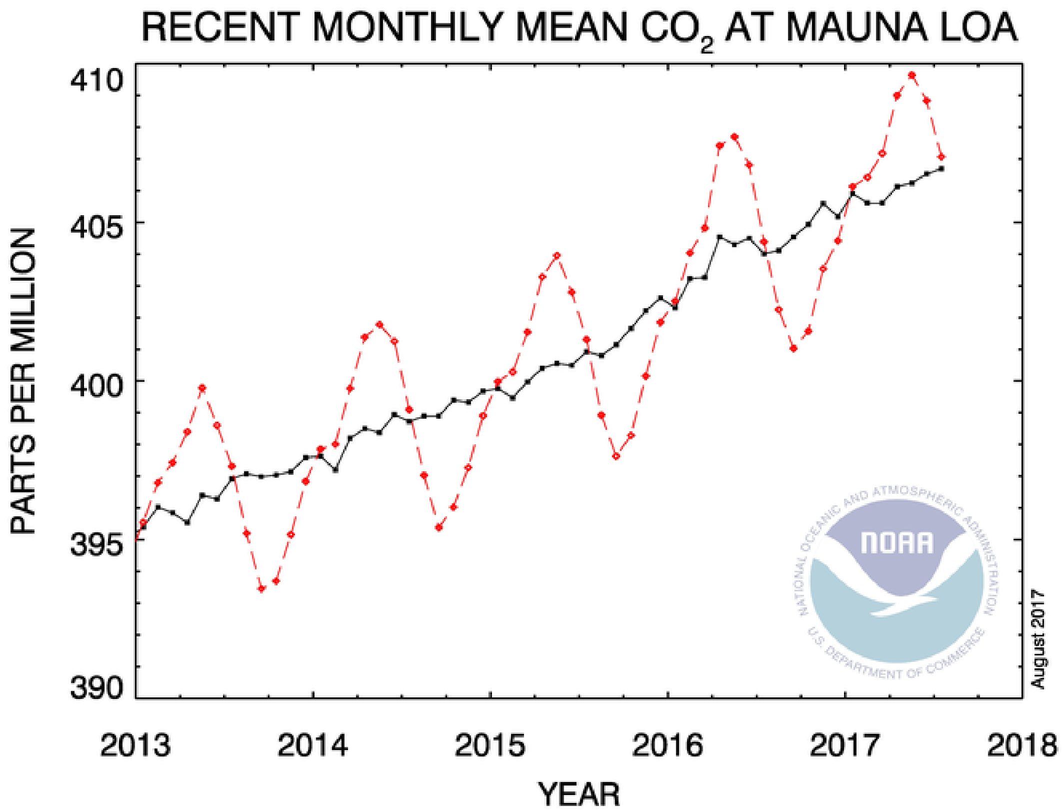

Figure 23. Monthly mean atmospheric carbon dioxide concentrations measured at Mauna Loa Observatory, Hawaii. (Data from NOAA Earth System Research Laboratory, Global Monitoring Division, available at https://www.esrl.noaa.gov/gmd/ccgg/trends/index.html, accessed August 7, 2017).

As the oceans absorb more CO_2, the pH of seawater is reduced. This process is commonly referred to as ocean acidification. Ocean acidification reduces the saturation states (Ω) of certain biologically important calcium carbonate minerals like aragonite and calcite that many organisms use to form and maintain shells (Reisdorph and Mathis 2014). When seawater is supersaturated with these minerals ($\Omega>1$), calcification (growth) of shells is favored. Likewise, when $\Omega<1$, dissolution is favored (Feely et al. 2009).

High latitude oceans have naturally lower saturation states of calcium carbonate minerals than more temperate or tropical waters (Fabry et al. 2009; Jiang et al. 2015), making Alaska's oceans more susceptible to the effects of ocean acidification. Large inputs of low-alkalinity freshwater from glacial runoff and melting sea ice reduce the buffering capacity of seawater to changes in pH (Reisdorph and Mathis 2014). As a result, seasonal undersaturation of aragonite has been detected in the Bering Sea at sampling stations near the outflows of the Yukon and Kuskokwim rivers (Fabry et al. 2009), Glacier Bay (Reisdorph and Mathis 2014), and the Chukchi Sea (Fabry et al. 2009). By 2050, all of the Arctic Ocean is predicted to be undersaturated with respect to aragonite (Feely et al. 2009).

Changes in seawater chemistry as a result of ocean acidification could have severe consequences for calcifying organisms, particularly pteropods. Pteropods are a type of zooplankton that form shells from aragonite, are abundant in high latitude surface waters, and form the base of many food webs (Orr et al. 2005). Pteropods are prey for many species of carnivorous zooplankton; fishes including salmon, mackerel, herring, and cod; and baleen whales (Orr et al. 2005), and are often considered an indicator species for ecosystem health. Under increasingly acidic conditions, pteropods may not be able to grow and maintain shells, and it is uncertain if they may be able to evolve quickly enough to adapt to changing ocean conditions (Fabry et al. 2009).

Ocean acidification may cause a variety of species- and ecosystem-level effects in high latitude ecosystems. Species-level effects may include reductions in the calcification rates of numerous planktonic and benthic species, alteration of physiological processes such as pH buffering, hypercapnia, ion transport, acid-base regulation, mortality, metabolic suppression, inhibited blood-oxygen binding, and reduced fitness and growth (Fabry et al. 2008). Ecosystem effects could include altered species compositions and distributions, trophic dynamics, rates of primary productivity, and carbon and nutrient cycling (Fabry et al. 2008).

Additionally, as the ocean becomes more acidic, low frequency sounds (1-3 kHz and below) travel farther because the concentrations of certain ions that absorb acoustic waves decrease with decreasing pH (Brewer and Hester 2009).

5.2 Fisheries

Commercial, subsistence, and recreational fisheries in the action area may harm or kill listed marine species through direct bycatch, gear interactions (entrapments and entanglements), vessel strikes, contaminant spills, habitat modification, competition for prey, and behavioral disturbance or harassment.

Worldwide, fisheries interactions have an impact on many marine mammal species. More than 97 percent of whale entanglements are caused by derelict fishing gear (Baulch and Perry 2014). There is also concern that mortality from entanglement may be underreported, as many marine mammals that die from entanglement tend to sink rather than strand ashore. Entanglement may also make marine mammals more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed.

Additionally, commercial fisheries may indirectly affect whales and seals by reducing the amount of available prey or affecting prey species composition. In Alaska, commercial fisheries target known prey species of ESA-listed whales, sea lions, and seals, such as pollock and cod, and bottom-trawl fisheries may disturb habitat for bottom-dwelling prey species of ESA-listed species.

Due to their highly migratory nature, many species considered in this opinion have the potential to interact with fisheries both in and outside of the action area. Assessing the impact of fisheries on such species is difficult due to the large number of fisheries that may interact with the animals and the inherent complexity of evaluating ecosystem-scale effects. The NMFS Bycatch Report estimates bycatch of marine mammals (and other taxa) from observer data and self-reported logbook data (NMFS 2016h). Additionally, under the MMPA, NMFS maintains an annual list of fisheries (LOF) that categorizes U.S. commercial fisheries according to the level of interactions that result in incidental mortality or serious injury of marine mammals.[26] Detailed information on U.S. commercial fisheries in Alaska waters, including observer programs and coverage and observed incidental takes of marine mammals, is presented in Appendices 3-6 of the Alaska Stock Assessment Reports (SARs) (Muto et al. 2017).

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) is the primary law that governs fishing in U.S. federal waters, ranging from 3 to 200 miles offshore. First passed in 1976, the MSA created eight regional fishery management councils to manage our nation's marine fishery resources. The North Pacific Fishery Management Council manages federal fisheries in Alaska. NMFS implements the policies and measures recommended by the Council.

The International Pacific Halibut Commission (IPHC) and NMFS manage fishing for Pacific halibut (*Hippoglossus stenolepis*) through regulations established under authority of the Northern Pacific Halibut Act of 1982 (Halibut Act). Within Alaska, the Council is responsible for allocating the halibut resource among users and user groups fishing off Alaska.

5.2.1 Fisheries of the BSAIRA and GOARA

Groundfish fisheries (including pollock, cod, flatfish, sablefish, rockfish, and other species) of the BSAI and GOA are managed under separate but complementary fishery management plans (FMPs) developed by the Council.[26] By regulation, up to 2 million metric tons of groundfish may be harvested annually from the BSAI, and up to 800,000 metric tons of groundfish may be harvested annually from the GOA (50 CFR 679.20(a)). In 2018, 2 million metric tons of groundfish were authorized for harvest in the BSAI, and approximately 427,000 metric tons of groundfish were authorized for harvest in the GOA. Nearly 80% of the halibut apportioned to Alaska is allocated to fisheries in the Gulf of Alaska (including Southeast Alaska). The remainder is allocated and harvested in the BSAI.

NMFS manages 10 stocks of crab in the BSAI under an FMP, and the State of Alaska manages the remaining crab stocks. Pot gear is the primary gear type used in the directed crab fisheries. In 2016, more than 29,000 metric tons of crab were harvested in the Federal crab fisheries in the BSAI (Garber-Yonts and Lee 2017).

In 2010, NMFS conducted a formal ESA section 7 consultation on the continued authorization of the groundfish fisheries of the BSAI and GOA, including the state parallel fisheries. In that opinion, NMFS concluded that the groundfish fisheries, as proposed, would result in takes of animals from the Central North Pacific stock of humpback whales, Western North Pacific stock of humpback whales, Northeast Pacific stock of fin whales, North Pacific stock of sperm whales,

26 North Pacific Fishery Management Council, Available at https://www.npfmc.org/, accessed October 6, 2010.

and both DPSs of Steller sea lions. Take for these stocks and species was authorized, subject to reasonable and prudent measures and the terms and conditions outlined in that opinion (NMFS 2010a). NMFS reinitiated consultation in 2013 for only the western DPS of Steller sea lion to evaluate a new suite of protection measures that were designed to avoid jeopardy of the western DPS of Steller sea lion. The resulting 2014 Biological Opinion concluded that prosecution of the groundfish fisheries under the revised sea lion protection measures was not likely to result in jeopardy or adverse modification of critical habitat (NMFS 2014).

Commercial fisheries' interactions with Steller sea lions in the GOARA and BSAIRA are mitigated by various protection measures put in place to reduce competition for prey and other stressors associated with fishing. These measures aim to protect Steller sea lion prey from potential effects of groundfish fishing by temporally and geographically dispersing commercial catches through a variety of harvest limitations and closure areas. Many of these measures apply specifically to Atka mackerel, Pacific cod, and pollock, which are important prey for Steller sea lions. To protect Steller sea lion prey availability, these measures use a precautionary approach to the management of Steller sea lion prey species by spatially and temporally dispersing catch, particularly in critical habitat, to prevent localized prey depletion. The protection measures regulate fishing through a combination of closed areas, harvest limits, and seasons that reduce fishery competition for Steller sea lion prey when and where Steller sea lions forage. A complete chronology and description of the Steller sea lion protection measures is provided in NMFS (2014).

Salmonid Catch and Bycatch in Commercial Fisheries

The take of ESA-listed salmon ESUs in the ocean and in-river salmon fisheries of the U.S. west coast has been analyzed by the NMFS in a number of biological opinions and in each of these, NMFS found that salmon directed fisheries would not jeopardize the continued existence of ESA-listed salmon or NMFS has provided reasonable and prudent alternatives to avoid jeopardy. The salmon fisheries, both ocean harvest and in-river harvest, are managed to avoid jeopardy by meeting escapement objectives to protect ESA-listed and non-ESA-listed populations.

Salmon are caught incidentally in commercial fisheries off the U.S. west coast, including: the bottom trawl and whiting components of the groundfish fishery off the coasts of Washington, Oregon, and California; and purse seine fisheries that target coastal pelagic species such as sardines and squid. A number of section 7 consultations have been conducted to determine effects of the fishery on ESA-listed salmon. In each of the consultations, NMFS has determined that the incidental take of salmon in the fishery would not likely jeopardize the continued existence of the ESUs (mostly Chinook) under consideration.

Green Sturgeon Fisheries Bycatch

The operation of the Federal (Pacific Coast) groundfish fishery and the state-managed California halibut bottom trawl fishery has resulted in past and present impacts on green sturgeon incidentally caught in these fisheries. Although retention of green sturgeon is prohibited, some portion of the green sturgeon incidentally caught dies immediately or after being released back into the water. Because Southern DPS green sturgeon are not morphologically distinguishable from Northern DPS green sturgeon, the effects of these fisheries described below are not specific to Southern DPS green sturgeon. To estimate the effects of these fisheries on Southern DPS green sturgeon, we used stock composition information from genetic and tagging studies to estimate the proportion of the green sturgeon incidentally caught that may belong to the Southern DPS.

The limited entry (LE) groundfish bottom trawl sector and the at-sea Pacific hake/whiting sector (at-sea hake sector) of the Pacific Coast Groundfish Fishery have incidentally caught green sturgeon in the past (Al-Humaidhi et al. 2012). Incidental catch of green sturgeon in these fisheries has varied over the years. The LE groundfish bottom trawl sector encountered an estimated 0 to 43 green sturgeon per year from 2002 through 2010 (Al-Humaidhi et al. 2012). Based on the location of the encounters[27] and data on green sturgeon stock composition in marine and coastal estuarine waters (Israel et al. 2009; Israel and May 2010), we estimate that the majority of the green sturgeon encountered likely belonged to the Southern DPS, with a range of 0 to 39 Southern DPS green sturgeon encounters per year from 2002 through 2010. Almost all the fish were released alive. In the at-sea hake sector, only three green sturgeon were encountered and observed in the period from 1991 through 2011 and all had died because of the encounter (Al-Humaidhi et al. 2012) (Vanessa Tuttle, pers. comm., A-SHOP, July 23, 2012). Data are not available to determine if the fish belonged to the Southern DPS or Northern DPS. A-SHOP data include two additional records of unidentified sturgeon encountered and observed during the 1990s (Vanessa Tuttle, pers. comm., A-SHOP, August 17, 2012).

Green sturgeon are encountered in the state-regulated California halibut bottom trawl fishery conducted in coastal marine waters. From 2002 through 2010, an estimated 86 to 786 green sturgeon encounters occurred per year in the fishery (Al-Humaidhi et al. 2012). It is possible that individual green sturgeon are encountered by the fishery more than once per year, but recapture rates are not known. The majority of the green sturgeon encountered likely belonged to the Southern DPS, based on the location of the encounters (primarily in coastal marine waters adjacent to San Francisco Bay) (Al-Humaidhi et al. 2012) and data on green sturgeon stock composition in marine waters and coastal estuaries of California (Israel et al. 2009; Israel and May 2010). We estimate that from 2002 through 2010, the fishery had 86 to 786 encounters with Southern DPS green sturgeon per year. Changes in state fishing regulations were implemented in 2006 to reduce access to the California halibut fishery (California Fish and Game Code Section 8494) and appear to have decreased total California halibut landings and the number of encounters with green sturgeon per year. The estimated encounters with Southern DPS green

[27] West Coast Groundfish Observer Program and NWFSC. 2011. West Coast Groundfish Observer Program In-Season Salmon Reporting. https://www.nwfsc.noaa.gov/research/datatech/data/wcgop_in_season_reporting.cfm, Accessed 2011.

sturgeon ranged from 86 to 289 per year from 2007 through 2010, compared to 152 to 786 per year from 2002 through 2006 (Al-Humaidhi et al. 2012). Thus, the level of encounters has been reduced compared to historical levels. Based on the 2007 through 2010 bycatch data, we estimate that the California halibut bottom trawl fishery encounters 86 to 289 Southern DPS green sturgeon per year. Applying a bycatch mortality rate of 5.2 percent, we estimate that encounters in the California halibut bottom trawl fishery kills 5 to 15 Southern DPS green sturgeon per year.

5.2.2 Fisheries of the CSBSRA

The NPFMC also adopted an Arctic FMP[26], which closed all Federal waters of the Chukchi and Beaufort seas to commercial fishing for any species of finfish, mollusks, crustaceans, and all other forms of marine animal and plant life, with limited exceptions. The Arctic FMP does not regulate subsistence or recreational fishing or State of Alaska-managed fisheries in the Arctic.

Because no commercial fisheries occur in the CSBSRA, any observed serious injury or mortality to listed species in the Arctic that can be associated with commercial fisheries is currently attributable to interactions with fisheries in other areas, including the BSAIRA and GOARA. For example, bowhead whales in the Arctic have been observed entangled in pot fishing gear thought to be from the Bering Sea (see Status of Species section and Muto et al. (2017)).

5.3 Entanglement

Entanglement of pinnipeds and cetaceans in fishing gear and other human-made material is a major threat to their survival worldwide. Other materials also pose entanglement risks including marine debris, mooring lines, anchor lines, and underwater cables. While in many instances marine mammals may be able to disentangle themselves (see Jensen et al. (2009)), other entanglements result in lethal and sublethal trauma to marine mammals including drowning, injury, reduced foraging, reduced fitness, and increased energy expenditure (van der Hoop et al. 2016).

Entangled marine mammals may drown or starve due to being restricted by gear, suffer physical trauma and systemic infections, and/ or be hit by vessels due to an inability to avoid them. Entanglement can include many different gear interaction scenarios, but the following have occurred with listed species covered in this opinion:

- Ingestion of gear and/or hooks can cause serious injury depending on whether the gear works its way into the gastrointestinal (GI) tract, whether the gear penetrates the GI lining, and the location of the hooking (*e.g.*, embedded in the animal's stomach or other internal body parts) (Andersen et al. 2008).
- Gear loosely wrapped around the marine mammal’s body that moves or shifts freely with the marine mammal’s movement and does not indent the skin can result in disfigurement.
- Gear that encircles any body part and has sufficient tension to either indent the skin or to not shift with marine mammal’s movement can cause lacerations, partial or complete fin

amputation, organ damage, or muscle damage and interfere with mobility, feeding, and breathing. Chronic tissue damage from line under pressure can compromise a whale's physiology. Fecal samples from entangled whales had extremely high levels of cortisols (Rolland et al., 2005), an immune system hormone. Extended periods of pituitary release of cortisols can exhaust the immune system, making a whale susceptible to disease and infection.

The NMFS Alaska Marine Mammal Stranding Network database has records of 199 large whale entanglements between 1990 and 2016. Of these, 67% were humpback whales. Gray, beluga, bowhead, fin, and sperm whales have also been reported as entangled in Alaska waters over the past decade. Most humpbacks get entangled with gear between the beginning of June and the beginning of September, when they are on their nearshore foraging grounds in Alaska waters. Between 1990 and 2016, 29% of humpback entanglements were with pot gear and 37% with gillnet gear. Longline gear comprised only 1 - 2% of all humpback fishing gear interactions.

There have been 5 takes of cetaceans in research activities. One animal was entangled in ADFG test drift gillnet in 1993. In 1999, 2 animals were found dead, entangled in the *R/V Cobb's* pollock research trawl gear. A whale drowned after becoming entangled in ADFG herring research seine gear in 2006, and a whale became entangled in a salmon drift gillnet in 2016, apparently self-releasing from the gear.

Entanglement of pinnipeds in marine debris is common worldwide, and Laist (1997) reported that 79% of otariid species and 42% of phocid species have been entangled. In Southeast Alaska and British Columbia, Raum-Suryan et al. (2009) observed entanglement rates in marine debris of 0.26% in Steller sea lions. The most common entanglement material was plastic packing bands, and most entanglement materials appeared to originate from fishery activities. In Southeast Alaska, Steller sea lions also became entangled through ingestion of fishing gear; primarily salmon fishery flashers and longline hooks and line. Steller sea lions have also been entangled in trawl nets (Perez 2006).

5.4 Vessel Activity

Ferries, cruise ships, tankers, ore carriers, commercial fishing vessels, and recreational vessels transit or operate within Alaska state and EEZ waters. Much of the vessel traffic in Alaskan waters is concentrated in coastal areas of southeastern and southcentral Alaska during the summer months, where recreational vessels, charter vessels, commercial whale watch vessels, tour boats, and cruise ships are prevalent. Traffic from large vessels is more likely to occur year-round statewide, in both near shore and offshore waters, and includes commercial fishing vessels, freighters/tankers, passenger ferries, etc. In general, there is less vessel traffic off western and northern Alaska compared to other parts of the state, although considerable traffic passes through the Aleutian Islands via the Great Circle Route. These trends are changing with climate change-driven decreases in sea ice in the Bering, Chukchi, and Beaufort seas (Neilson et al. 2012).

Statewide, marine vessels are a known source of injury and mortality to marine mammals in Alaska, including some of the species considered in this Biological Opinion (Laist et al. 2001; Neilson et al. 2012). In addition to the potential for entanglement discussed in the sections above, vessel traffic may affect listed species through collisions (strikes) and increased ocean noise. Vessel traffic also has the potential to impact species via pollution from discharges and spills, and behavioral disruption (e.g., interference with foraging or migration, disturbance while resting or hauled-out).

5.4.1 Vessel Activity in the GOARA

The Southeast Alaska Vessel Traffic Study prepared by Nuka Research in 2012 analyzed large vessel activity from Icy Bay to Dixon Entrance. In 2012, 28 cruise ships were scheduled to make 450 voyages through Southeast Alaska. The study estimated the future maximum cruise ship voyage capacity for Southeast Alaska to be 850 voyages per season. Cruise ships comprise 19 percent of large vessel activity (e.g., cruise ships, passenger vessels with overnight accommodations, freighters/tankers, and barges with tugs) in Southeast Alaska and typically operate in the area about five months out of the year. Ferries, passenger vessels with overnight accommodations, and cruise ships comprise 67 percent of the vessel activity. Dry freight cargo barges, tank barges, and freight ships (log and ore carriers) comprise another 30 percent of the vessel activity (Nuka Research and Planning Group 2012).

While the Nuka study focused on large vessels which are typically greater than 300 gross tons (GT), some information about smaller vessels can be inferred from a listing of all recreational boats registered in the State of Alaska through the Department of Motor Vehicles. In 2005, this statewide list included 29,267 registered boats 18’-25’ long and 4,540 boats longer than 25’(Brown May 2006).

Typically, two barges provide fuel for Southeast Alaska each month, carrying diesel, heating oil, aviation gas, and gasoline from Washington (and occasionally Nikiski) to replenish shore side tank farms. An additional ‘resident’ barge takes fuel from Ketchikan and provides supplies for the smaller communities or industrial activities (Nuka Research and Planning Group 2012). Relatively low log carrier activity (31 port calls in 2011) is expected to continue in Southeast Alaska. Ore concentrate bulk freight ship port calls (19 in 2011) may double with the expansion of the Skagway terminal and the development of Yukon zinc exports (Nuka Research and Planning Group 2012). Two freight barge companies provide approximately 180 service runs from Seattle to Southeast Alaska each year. Freight barges traveling to and from Western Alaska pass through the Inside Passage 150-190 times each year without stopping at a Southeast Alaska port (Nuka Research and Planning Group 2012).

The Alaska Marine Highway ferry service operated by the State of Alaska services 3,500 mi. of routes that go as far south as Bellingham, Washington and as far west as Unalaska/Dutch Harbor, Alaska. The highway system operates along the south-central coast of the state, the eastern Aleutian Islands, and the Inside Passage of Alaska and British Columbia. There are 32 terminals located in Washington, British Columbia, and Alaska.

Figure 24 depicts shipping vessel density provided by the automated identification system data for the area from Alaska to the Pacific Northwest in 2013. As evident from the graphic, commercial vessel use is highest in the U.S. EEZ, at straits and passages, and along least-distance line routes between ports.

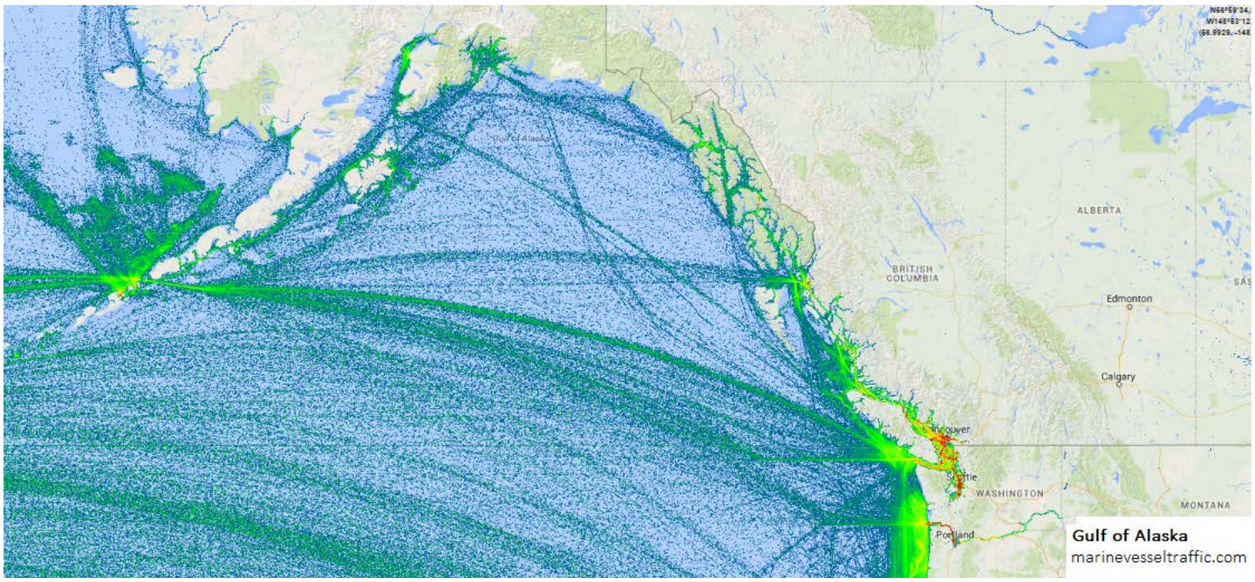

Figure 24. 2013 Shipping Traffic Density Map for the GOA (Available from, http://www.marinevesseltraffic.com)

5.4.2 Vessel Activity in the BSAIRA

The Great Circle Route between western North America and East Asia intersects the Aleutian Island chain. Approximately two thousand (1,961) large vessels (300 gross tonnage (GT) or greater) made 4,615 transits through Unimak Pass in 2012 (Figure 25). Most of the ships recorded through Unimak Pass were non-tank vessels: 60% of the individual vessels recorded were bulkers, 24% container ships, and 13% other non-tank vessels. Fifty-two vessels, or 3% of the total individual vessels recorded, were tankers. Many more vessels likely traveled through the EEZ south of the Aleutian Islands (Nuka Research and Planning Group 2015).

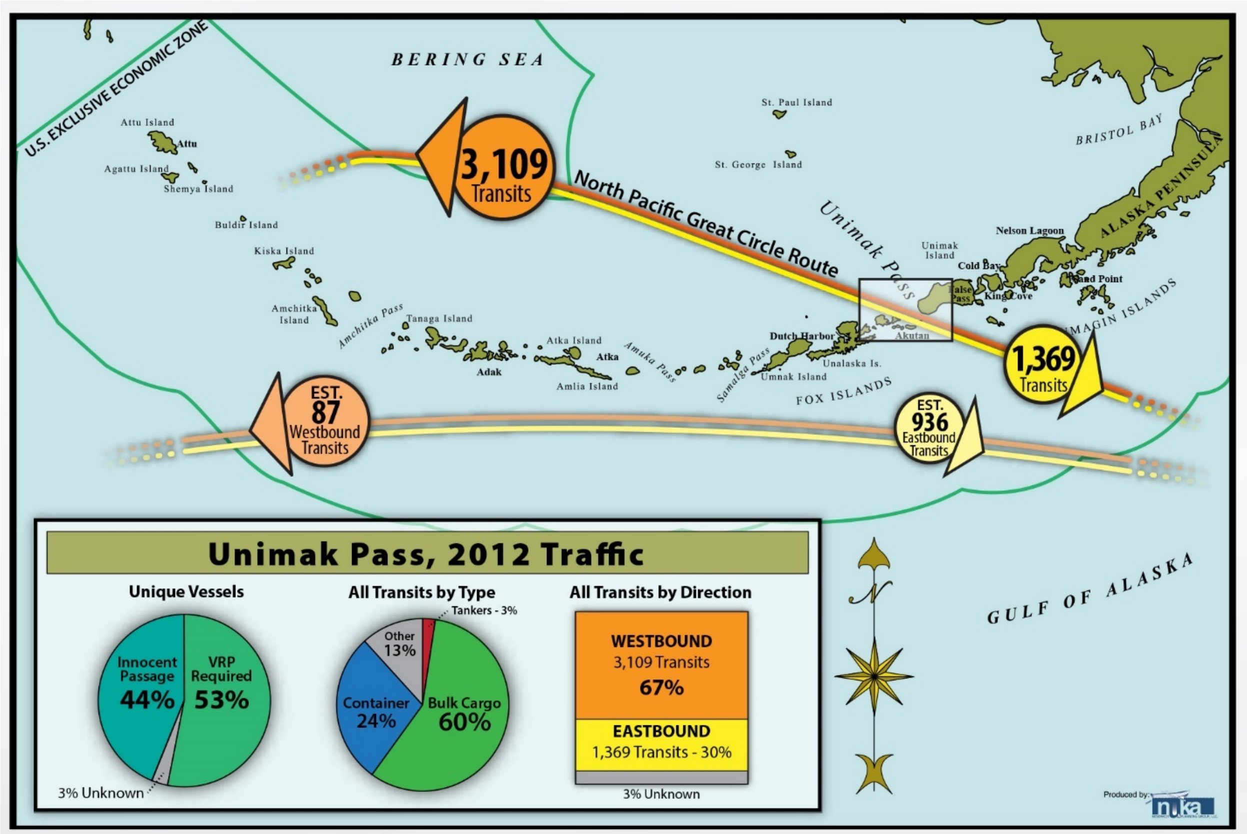

Figure 25. Summary of Unimak Pass traffic recorded in 2012, including percentage of vessels in innocent passage and by vessel type; also includes roughly estimated transits south of the island chain based on number of vessels going through Unimak Pass (Nuka Research and Planning Group 2015)

Proposed marine transportation projects in Washington State and British Columbia could significantly increase annual vessel transits through the region over the next 20 years. Trade through the region is estimated to increase incrementally each year, more than doubling eastbound container and chemical traffic in the next 25 years. Other studies have estimated an increase in vessel traffic to U.S. Pacific Northwest ports as between 1% and 9% per year through 2030 for container and bulk dry cargo ships (Nuka Research and Planning Group 2015).

Commercial fishing vessels account for the highest number of transits and the most operational hours in a 2015 Bering Sea Vessel Analysis prepared by Nuka Research. These vessels operate in the southern Bering Sea year-round, and deliver fish to processing plants in coastal communities. Container ships and refrigerated cargo ships transfer the processed seafood to global markets (Nuka Research and Planning Group 2016). Tankers, general cargo ships, and barges move throughout the eastern Bering Sea serving coastal and inland communities. Vessels also support industrial activities and resource extraction in the region, or move goods or materials through the area to European, Asian, and other North American ports. Research vessels, U.S. Coast Guard and other government vessels, recreational vessels, and, more frequently, cruise ships operate here as well.

The number of Bering Strait transits doubled from 2008 to 2015, and vessel traffic is expected to increase through the Bering Strait as Arctic sea ice retreats and both trans-Arctic shipping and the extraction of resources from Arctic countries grows (Nuka Research and Planning Group 2016).

5.4.3 Vessel Activity in the CSBSRA

Surface air temperatures in the Arctic Region are increasing at double the rate of the global average (Adams and Silber 2017). Continued expansion of the duration and extent of seasonal ice-free waters in the Chukchi and Beaufort Seas is anticipated over the coming decades, resulting in increased vessel traffic. However, sea ice is still prevalent for many months of the year, especially in the Beaufort where over 75% of the water surface area was covered by sea ice for nine months in 2015, resulting in only 483 vessel transits. Fishing vessels account for most of the vessel transit and operational hours in this region. However, as seasonal ice-free waters expand, the number of international commercial transport of goods and people in the area is projected to increase 100-500 percent in some Arctic areas by 2025 (Adams and Silber 2017).

5.4.4 Vessel Strikes

Collisions with vessels, or ship strikes, threaten numerous marine mammals and are of great concern for endangered large whales, particularly North Pacific right whales. Although the impact on the recovery of North Pacific right whale populations is not well understood, the potential for increased ship traffic in the North Pacific Ocean may pose a threat (NMFS 2013e). Ship strikes with marine mammals can lead to death by massive trauma, hemorrhaging, broken bones, or propeller wounds (Kraus et al. 2001). In Alaska, large whales, such as fin whales and humpback whales, are occasionally found draped across the bulbous bow of large ships.[28] While massive wounds can be immediately fatal, if injury is more superficial, whales may survive the collisions (Silber et al. 2010).

Information on the distribution of rare large whales is important to predict overlap with vessel traffic. Evidence of the critically endangered North Pacific right whale's use of the action area has been collected in recent years. Western GOA and southeastern BS are both frequently used areas (NMFS 2017g). Evidence of North Pacific right whale use of the Bering Sea follows:

- In the summer of 2004, 17 right whales were observed outside the middle-shelf domain in the southeastern BS (Wade et al. 2016),
- The observation of approximately 12 right whales just north of Unimak Pass in October 2005 (MML unpublished data),
- International Whaling Commission (IWC) POWER surveys from July to September 2017 reported 18 sightings of 12 North Pacific right whales in the southeastern Bering Sea and Bristol Bay area.
- Right whales were detected by passive acoustic monitoring over 5 years in Unimak Pass at various times, including in winter, supporting the idea that this pass is used by whales

[28] NMFS Alaska Marine Mammal Stranding Database, 2017, Available from https://alaskafisheries.noaa.gov/pr/strandings

entering and leaving the Bering Sea, possibly including during seasonal migration to a currently unknown wintering ground (Wright 2016).

- Numerous right whale detections have occurred in the critical habitat area of the southeastern Bering Sea, consistent with satellite tagging results and with numerous sightings of the species in this area.
- Overall, right whales have been recorded in the Bering Sea in most months of the year, with a peak occurrence in known foraging habitats in summer.

Wright (2016) also found acoustic evidence that North Pacific right whales occur in the northern Bering and southern Chukchi Seas, supported by a local experienced hunter's observation and historical records of right whales in the northeastern Bering Sea in summer and fall.

In the GOA, Rone et al (2015) acoustically detected right whales off Kodiak in 2013 and 2015. Širović et al. (2015) detected right whale calls on passive acoustic recorders at Quinn Seamount, and a potentially new individual was observed in 2017 between Kodiak and the Alaska Peninsula.

North Pacific right whales and other marine mammals' distributions in the Bering Sea, Gulf of Alaska, and Aleutian Islands, as described above and in the Status of the Species section, overlap with vessel traffic as shown in Figure 24 and Figure 25. Wright (2016) found high levels of sustained vessel noise at the Unimak Pass mooring (99.1% of days recorded vessel noise), overlapping substantially with North Pacific right whale up-calls and gunshot calls. In addition, consistent vessel noise occurred at northern moorings including the northern Bering Sea, Chirikov Basin in the Bering Strait, and the southern Chukchi Sea (Figure 26) during summer months when gunshot calls were documented. Areas like Bering Strait and the passes through the Aleutian Islands where vessels and marine mammals are concentrated in space likely elevate the risk of vessel strike.

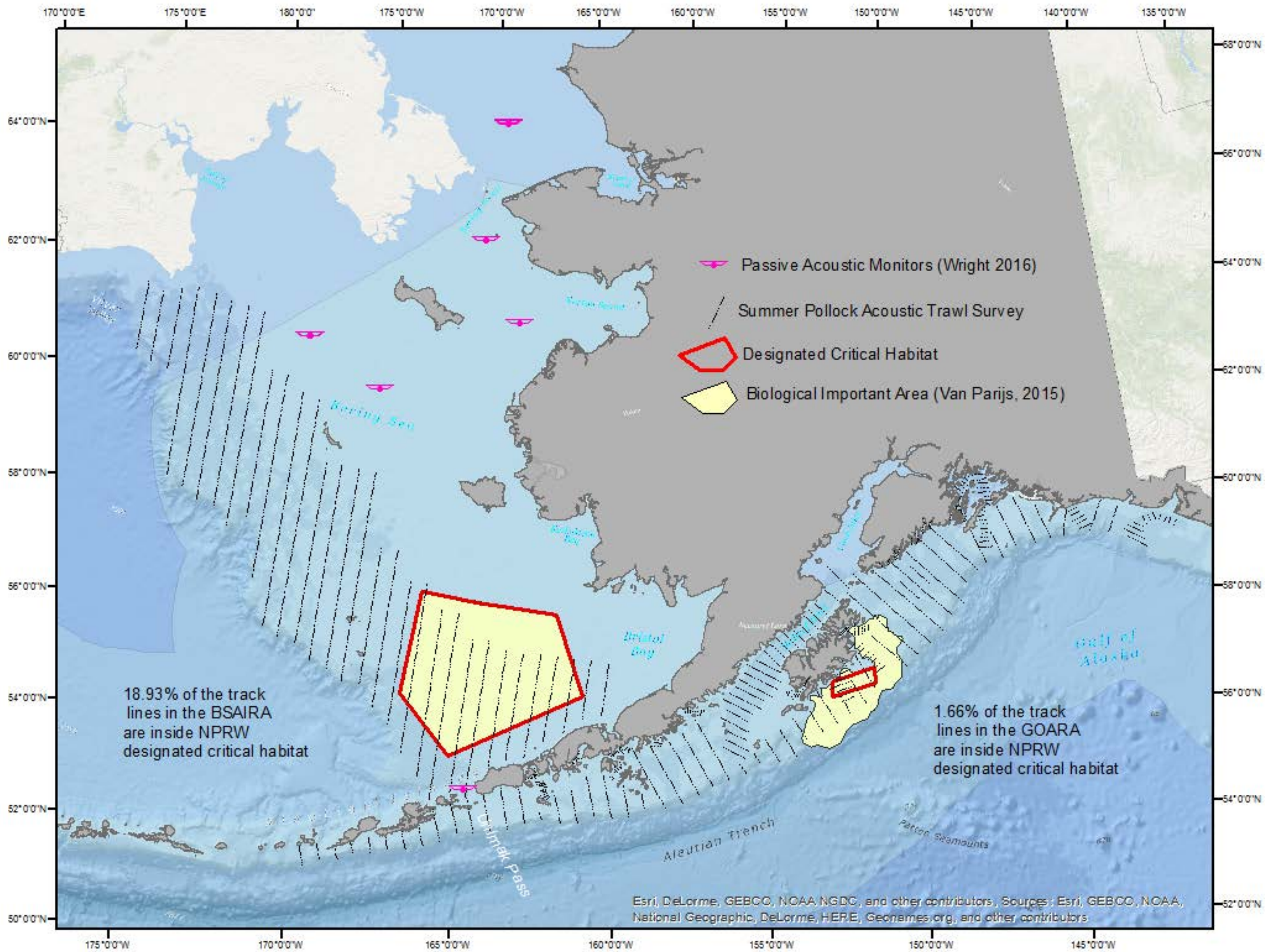

Figure 26. North Pacific right whale designated critical habitat, biological important areas, and passive acoustic monitors.

Williams and O'Hara (2010) summarized their modeling efforts to characterize ship strikes of large cetaceans in British Columbia. Their information on ship strikes was based on ship activity provided to them by the Canadian Coast Guard. Spatially-explicit statistical modeling and Geographic Information System visualization techniques identified areas of overlap between shipping activity and waters used by humpback, fin, and killer whales. Areas of highest risk were far removed from areas with high concentrations of people, suggesting that many beach-cast carcasses could go undetected. With few exceptions, high-risk areas were found in geographic bottlenecks, such as narrow straits and passageways.

Large numbers of cargo, fishing, cruise, and other ships transit the action area each year, and strikes occur through these waters. From 2012 to 2016 there were 31 incidents of vessel strike reported in the NMFS Alaska Region stranding database. While this averages to just over 6 strikes reported a year, 2012 saw 10 reported strikes. From 1978-2011, 108 whale-vessel collisions were reported within 200 miles of Alaska's coastline (Neilson et al. 2012). Most of these (86%) were humpback whales. Other species included fin whale, Cuvier's beaked whale, Stejneger's beaked whale, gray whale, and beluga whale (Neilson et al. 2012). In 15 of the 108 cases, whales struck anchored or drifting vessels, indicating that whales cannot always detect vessels (Neilson et al. 2012). Two ship-strike injuries were documented to bowhead whales out of a total of 236 bowhead whales examined from the Alaska Native subsistence harvest between 1976 and 1992 (George et al. 1994).

Neilson et al. (2012) summarized all known vessel strikes in Alaska (Figure 27 and Table 48). The vast majority of whale-vessel interactions in Alaska occur in Southeast Alaska where commercial vessel traffic coincides with large aggregations of humpback whales in narrow straits and passageways, just as Williams and O'Hara (2010) suggested in their study area.

Table 48 Summary of whale-vessel collisions including listed species, reported in Alaska, 1978-2011, adapted from Neilson et al. (2012).

Species	Total strikes (including definite, probable, and possible)	Number of known dead whales
Humpback[1]	93	17
Fin	3	2
Gray	1	1
Sperm	1	1
Cook Inlet Beluga DPS	1	1
[1]Distinct population segments unknown.		

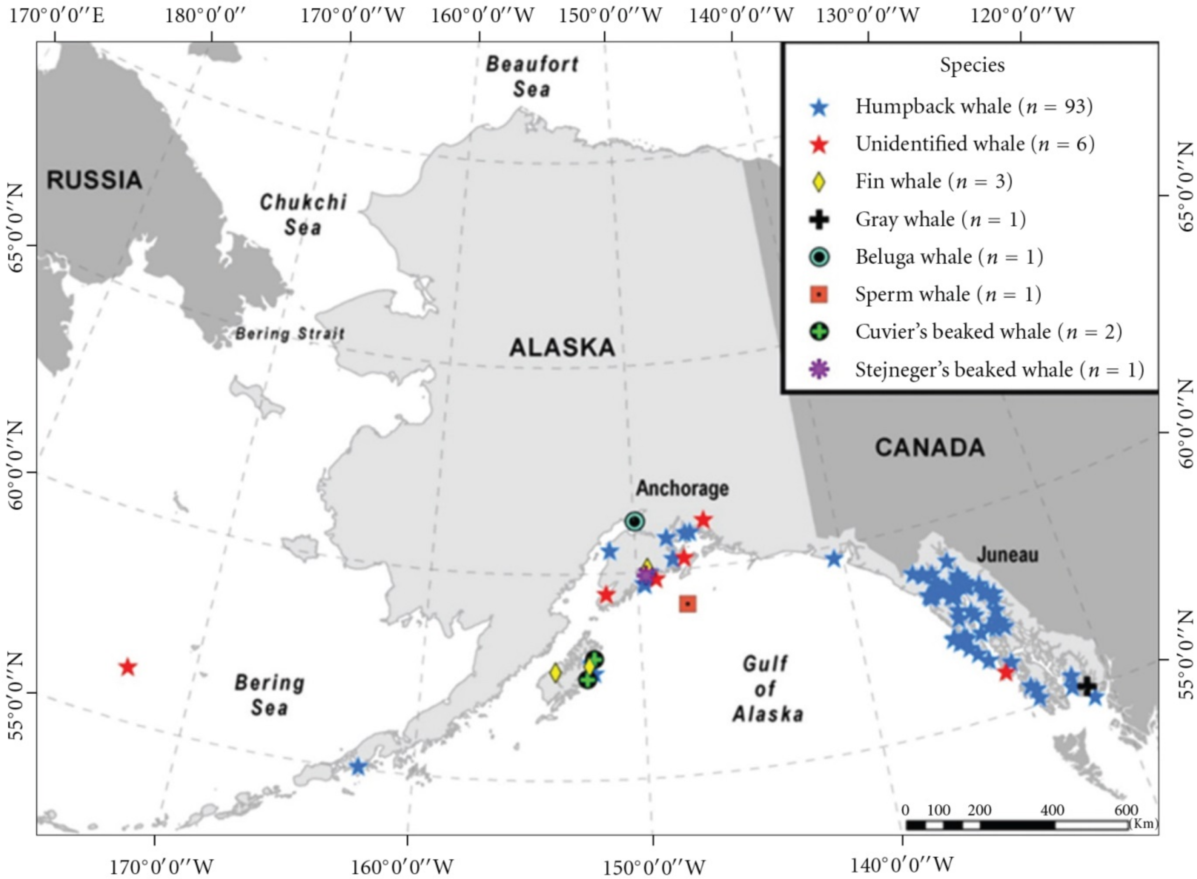

Figure 27: Location of whale-vessel collision reports in Alaska by species 1978–2011 (*n*=108). Rejected reports are not included (Neilson et al. 2012).

Although risk of vessel strike has not been identified as a significant concern for Steller sea lions (Loughlin and York 2000), the Recovery Plan for this species states that Steller sea lions may be more susceptible to ship strike mortality or injury in harbors or in areas where animals are concentrated (e.g., near rookeries or haulouts). Since 2000, there have been four reported ship strikes of Steller sea lions within Alaska, all in the GOARA (Table 49).

Table 49. Confirmed vessel strikes of Steller sea lions in Alaska since 2000. Data from NMFS Alaska Region Stranding Database (2017).

Year	Month	Area	Age	Sex	Length (cm)
2015	June	SE Alaska (Sitka)	unknown	unknown	unknown
2009	Apr	SE Alaska (Sitka)	adult	M	351 cm
2007	May	GOA	adult	F	114 cm

Year	Month	Area	Age	Sex	Length (cm)
2007	Apr	SE Alaska (Sitka)	unknown	unknown	unknown

Although strikes are regularly reported, the number that are fatal to listed species in Alaska appears to be low. There is no clear evidence that vessel strikes are having a population level impact on listed species considered in this Opinion.

5.4.5 Vessel Noise

Several investigators have argued that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (Horowitz and Jasny 2007; NRC 2003; Richardson et al. 1995a). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage world-wide (NRC 2003).

Commercial shipping traffic is a major source of low frequency (5 to 500 Hz) human generated sound in the world's oceans (NRC 2003; Simmonds and Hutchinson 1996). The radiated noise spectrum of merchant ships ranges from 20 to 500 Hz and peaks at approximately 60 Hz. Ross (Ross 1976) estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB. Based on his estimates, Ross predicted a continuously increasing trend in ocean ambient noise of 0.55 dB per year. Chapman and Price (2011) recorded low frequency deep ocean ambient noise in the Northeast Pacific Ocean from 1976 to 1986 and reported that the trend of 0.55 dB per year predicted by Ross (1976) persisted until at least around 1980. Afterward, the increase per year was significantly less, about 0.2 dB per year. Greene and Moore (1995) found that shipping sounds are often at source levels of 150-190 dB re 1 µPa at 1 meter, and shipping traffic mostly occurs at frequencies from 20-300 hertz.

Greene and Moore (1995) also studied sound produced by smaller boats and found that small boats typically generate noise at a higher frequency, around 300 hertz. They found that in shallow water, vessels more than 6.2 miles away from a receiver generally contribute only to background-sound levels.

Icebreaking vessels used in the Arctic for activities including research and oil and gas activities produce louder, but also more variable, sounds than those associated with other vessels of similar power and size. The greatest sound generated during ice-breaking operations is produced by cavitation of the propeller as opposed to the engines or the ice on the hull; estimated source levels for icebreakers range from 177-191 dB re 1 µPa 1 meter (Greene and Moore 1995). Even with rapid attenuation of sound in heavy ice conditions, the elevation in noise levels attributed to icebreaking can be substantial out to at least 3 miles. In some instances, icebreaking sounds are detectable from more than 31 miles away (Greene and Moore 1995).

Williams et al. (2014) measured ocean noise levels at 12 sites in the Canadian Pacific Ocean, including Haro Strait, and reported that noise levels were high enough to reduce the communication spaces for fin, humpback, and killer whales under typical (median) conditions by 1, 52 and 62 percent, respectively, and 30, 94 and 97 percent under noisy conditions.

Bassett et al. (2012) paired one year of AIS data with hydrophone recordings in Puget Sound's Admiralty Inlet to assess ambient noise levels and the contribution of vessel noise to these levels. Results suggested ambient noise levels between 20 Hz and 30 kHz were largely driven by vessel activity and that the increases associated with vessel traffic were biologically significant. Throughout the year, at least one AIS-transmitting vessel was within the study area 90 percent of the time and multiple vessels were present 68 percent of the time. A vessel noise budget showed cargo vessels accounted for 79 percent of acoustic energy, while passenger ferries and tugs had lower source levels but spent substantially more time in the study site and contributed 18 percent of the energy in the budget. All vessels generated acoustic energy at frequencies relevant to all marine mammal functional hearing groups.

Urick (1983) provided a discussion of the ambient noise spectrum expected in the deep ocean. Shipping, seismic activity, and weather are primary causes of deep-water ambient noise. Noise levels between 20 and 500 Hz appear to be dominated by distant shipping noise that usually exceeds wind-related noise. Above 300 Hz, the level of wind-related noise might exceed shipping noise. Wind, wave, and precipitation noise originating close to the point of measurement dominate frequencies from 500 to 50,000 Hz. The ambient noise frequency spectrum and level can be predicted fairly accurately for most deep-water areas based primarily on known shipping traffic density and wind state (wind speed, Beaufort wind force, or sea state) (Urick 1983). For frequencies between 100 and 500 Hz, Urick (1983) has estimated the average deep water ambient noise spectra to be 73 to 80 dB for areas of heavy shipping traffic and high sea states, and 46 to 58 dB for light shipping and calm seas.

In contrast to deep water, ambient noise levels in shallow waters (i.e., coastal areas, bays, harbors, etc.) are subject to wide variations in level and frequency depending on time and location. The primary sources of noise include distant shipping and industrial activities, wind and waves, and marine animals (Urick 1983). At any given time and place, the ambient noise level is a mixture of these noise types. In addition, sound propagation is also affected by the variable shallow water conditions, including the depth, bottom slope, and type of bottom. Where the bottom is reflective, the sound levels tend to be higher than when the bottom is absorptive.

Galli et al. (2003) measured ambient noise levels and source levels of whale-watch boats in Haro Strait. They measured ambient noise levels of 91 dB (at frequencies between 50 and 20,000 Hz) on extremely calm days (corresponding to sea states of zero) and 116 dB on the roughest day on which they took measurements (corresponding to a sea state of ~5). Mean sound spectra from acoustic moorings set off Cape Flattery, Washington, showed that close ships dominated the sound field below 10 kHz while rain and drizzle were the dominant sound sources above 20 kHz.

At these sites, shipping noise dominated the sound field about 10 to 30 percent of the time but the amount of shipping noise declined as weather conditions deteriorated. The large ships they measured produced source levels that averaged 184 dB at 1 m ± 4 dB, which was similar to the 187 dB at 1 m reported by Greene and Moore (1995).

Kipple and Gabriele (2007) measured sounds emitted from 38 vessels ranging in size from 14 to 962 feet at speeds of 10 knots and at a distance of 500 yards from the hydrophone in Glacier Bay, Southeast Alaska. Sound levels ranged from a minimum of 157 to a maximum of 182 dB re 1 µPa@1 m, with sound levels showing an increasing trend with both increasing vessel size and with increasing vessel speed. Vessel sound levels also showed dependence on propulsion type and horsepower. Vessel noise can result from several sources including propeller cavitation, vibration of machinery, flow noise, structural radiation, and auxiliary sources such as pumps, fans, and other mechanical power sources. McKenna et al. (2012) measured radiated noise from several types of commercial ships, combining acoustic measurements with ship passage information from AIS. On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 lPa^2 20 to 1,000 Hz), despite major differences in size and speed. Differences in the dominant frequency of radiated noise were found to be related to ship type, with bulk carrier noise predominantly near 100 Hz while container ship and tanker noise was predominantly below 40 Hz. The tanker had less acoustic energy in frequencies above 300 Hz, unlike the container and bulk carrier.

5.5 Ocean Noise

In addition to vessel noise described above, ESA-listed species in the action area are exposed to several other sources of natural and anthropogenic noise. Natural sources of underwater noise include sea ice, wind, waves, precipitation, and biological noise from marine mammals, fishes, and crustaceans. Other anthropogenic sources of underwater noise of concern to listed species in Alaska include in-water construction activities such as drilling, dredging, and pile driving; oil, gas, and mineral exploration and extraction; Navy sonar and other military activities; geophysical seismic surveys; and ocean research activities. Noise impacts to listed marine mammal species state-wide from many of these activities are mitigated through ESA Section 7 consultations.

Levels of anthropogenic (human-caused) sound can vary dramatically depending on the season, type of activity, and local conditions. The combination of anthropogenic and natural noises contributes to the total noise at any one place and time.

Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals. As described in greater detail later in this opinion, noise may cause marine mammals to leave a habitat, impair their ability to communicate, or to cause stress. Noise can cause behavioral disturbances, mask other sounds including their own vocalizations, may result in injury, and, in some cases, may result in behaviors that ultimately lead to death. The severity of these impacts can vary greatly between minor impacts that have no real cost to the animal, to more severe impacts that may have lasting consequences. A comprehensive discussion of the potential impacts of ocean noise on listed species is included in the *Effects of the Action* section of this opinion.

Because responses to anthropogenic noise vary among species and individuals within species, it is difficult to determine long-term effects. Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Clark et al. (2009) identified increasing levels of anthropogenic noise as a habitat concern for whales because of its potential effect on their ability to communicate (i.e., masking). Some research (McDonald et al. 2006; Parks 2003; Parks 2009) suggests marine mammals compensate for masking by changing the frequency, source level, redundancy, and timing of their calls. However, the long-term implications of these adjustments, if any, are currently unknown.

5.6 Subsistence Harvest of Marine Mammals

Subsistence harvest by Alaska Natives is another source of injury or mortality for endangered and threatened species in Alaskan waters. Table 50 lists endangered and threatened subsistence species and the research areas in which they are harvested. Section 3.3.4 of the NEPA analysis of this action provides further details on subsistence harvests in AFSC research areas.

Table 50. ESA-listed marine mammal species harvested by Alaska Natives for subsistence purposes in the action area (NMFS 2017b).

Species	GOARA	BSAIRA	CSBSRA
Bowhead whale		X	X
Steller sea lion, Western DPS	X	X	
Bearded seal		X	X
Ringed seal		X	X

5.6.1 Subsistence Harvest in the GOARA

The western DPS of Steller sea lion is the only listed species under NMFS' jurisdiction subject to subsistence harvest in the GOARA. Annual statewide data on community subsistence harvest of Steller sea lions are no longer collected as of 2009; data were collected for seven communities around Kodiak Island in 2011, where an estimated 20 adult Steller sea lions were harvested. The minimum mean annual statewide subsistence take from this stock for all areas except St. Paul Island for 2004-2008, plus the annual take from St. Paul Island for 2010-2014, was 201 Steller sea lions per year (Muto et al. 2017), but this estimate does not include areas where harvest is not monitored.

5.6.2 Subsistence Harvest in the BSAIRA

Threatened and endangered species under NMFS jurisdiction subject to subsistence harvest in the BSAIRA are the western DPS of Steller sea lion, ringed seal, and bearded seal. The statewide annual subsistence harvest of Steller sea lions is summarized in the paragraph above, and in the Status of the Species section describing Steller sea lions. Ringed and bearded seals are also important subsistence species for Alaska Natives. Only 12 of the 64 coastal communities known to harvest bearded seals and ringed seals were surveyed from 2009 to 2013, so statewide harvest estimates are not available. Based on the harvest data from these 12 surveyed communities, minimum estimates of the average annual bearded seal and ringed seal harvests Alaska-wide for 2009-2013 are 390 and 1,050 seals per year, respectively (Muto et al. 2017). Bearded and ringed seal harvests include harvests from villages and communities in the BSAIRA and in the CSBSRA.

5.6.3 Subsistence Harvest in the CSBSRA

Threatened and endangered species under NMFS jurisdiction and subject to subsistence harvest in the CSBSRA include bowhead whales, ringed seals, and bearded seals. The subsistence harvest by Alaska Natives is the single greatest source of human-caused mortality of the Western Arctic stock of bowhead whales. See the Status of Species section for estimates of subsistence harvests by species.

5.7 Illegal Shooting

Illegal shooting of listed species occurs to an unknown extent in the action area. The Steller Sea Lion Recovery Plan (NMFS 2008) ranked illegal shooting as a low threat to the recovery of the western DPS. Illegal shooting of sea lions was thought to be a potentially significant source of mortality prior to the listing of sea lions as threatened under the ESA in 1990.

On June 1, 2015, the NMFS Alaska Marine Mammal Stranding Program received reports of at least five dead Steller sea lions on the Copper River Delta. Two NMFS biologists recorded at least 18 pinniped carcasses, most of which were Steller sea lions, on June 2, 2015. A majority of the carcasses had evidence that they had been intentionally killed by humans. Subsequent surveys located two additional Steller sea lion carcasses, which may also have been intentionally killed.

In April 2018, two men were criminally charged in connection with the 2015 case: the captain, Jon Nichols, and the crew member, Theodore Turgeon. They were charged with harassing and killing Steller sea lions with shotguns and then making false statements and obstructing the government's investigation into their criminal activities, and the charges included: conspiracy, violations of the Marine Mammal Protection Act and Endangered Species Act, obstruction of a Marine Mammal Protection Act investigation, false statements, and obstruction. In late June 2018, the men plead guilty to the following criminal charges:

Nichols (Captain)

- -Plead guilty to illegal take of marine mammal (Count two - Marine Mammal Protection Act - Illegal Take, in violation of 16 U.S.C. 1372(a)(2)(A),1375(b))
- -Plead guilty to obstruction of MMPA investigation (Count four - Obstruction of an MMPA Investigation, in violation of 16 U.S.C. 1373, 1375(b) and 50 C.F.R 216.17)

Turgeon (crewman)

- -Plead guilty to illegal take of marine mammal (Count two - Marine Mammal Protection Act - Illegal Take, in violation of 16 U.S.C. 1372(a)(2)(A), 1375(b))

NMFS Alaska Region designed survey plans for the Copper River Delta in 2016-2018 focused on the time period of greatest overlap between the salmon driftnet fishery and marine mammals. The purpose of the surveys was to determine if the intentional killing observed in 2015 continued, and to collect cause of death evidence and samples for health assessments. Intentional killing by humans appears to be continuing and was the leading known cause of death of the pinnipeds assessed on the Copper River Delta from May 18 to August 17, 2017 (Wright and Savage, 2017). It is unlikely that the presence of the carcasses observed in the 2016 and 2017 surveys would have been reported without these dedicated surveys in this remote area. Without dedicated monitoring in past years it is impossible to know whether intentional killings by humans increased in 2015- 20 17 relative to prior years. Numbers of marine mammals found dead with evidence of human interaction dropped considerably between 2015 and 2016, but increased between 2016 and 2017.

5.8 Marine Debris

Marine debris is any persistent solid material that is manufactured or processed and directly (such as dumping) or indirectly (such as washing out to sea), intentionally or unintentionally, disposed of or abandoned in the marine environment.[29] Marine debris degrades marine habitat quality, poses ingestion and entanglement risks to marine life, and may introduce invasive species. Marine debris may also leach or absorb hazardous materials which are harmful to marine life. Worldwide, about 80% of marine debris is now made up of plastic items. Plastics are non-biodegradable and persist in the environment. Marine debris entanglement of pinnipeds and whales is described in the section on entanglements above.

5.9 Scientific Research

In the following sections, we describe the types of scientific research currently permitted for ESA-listed cetaceans and pinnipeds in the action area. NMFS issues scientific research permits that are valid for five years for ESA-listed species. NMFS conducts section 7 consultations on

29NOAA website, https://oceanservice.noaa.gov/facts/marinedebris.html, Accessed January 23, 2018.

the issuance of these permits, including permits for research conducted by AFSC. When permits expire, researchers often apply for a new permit to continue their research. Additionally, applications for new permits are issued on an on-going basis; therefore, the number of active research permits is subject to change. There are more than 30 active permits for research on cetaceans and pinnipeds throughout Alaska. The NMFS database of authorizations and permits for protected species (APPS) is available online at https://apps.nmfs.noaa.gov/.

Species considered in this opinion also occur in Canadian waters. Although we do not have specific information about any permitted research activities in Canadian waters, we assume they will be similar to those described below.

5.9.1 Cetacean Research

Whales are exposed to research activities documenting their biology, behavior, habitat use, stock structure, social organization, communication, distribution, and movements throughout their ranges. Activities associated with these permits occur in the action area, in some cases at the same time as the proposed project activities.

Currently permitted research activities include:

- Counting/surveying, aerial and vessel-based
- Opportunistic collection of sloughed skin and remains
- Behavioral and monitoring observations
- Various types of photography and videography
- Skin and blubber biopsy sampling
- Fecal sampling
- Suction-cup, dart/barb, satellite, and dorsal fin/ridge tagging
- Acoustic, active playback/broadcast, and passive recording
- Acoustic sonar for prey mapping

Some of these research activities require close vessel approach. The permits also include incidental harassment takes to cover such activities as tagging, where the research vessel may come within 100 yards of other whales while in pursuit of a target whale. These activities may cause stress to individual whales and cause behavioral responses. In some cases, take could occur and is authorized.

5.9.2 Pinniped Research

Steller sea lions, ringed seals, and bearded seals are exposed to research activities documenting their population status and trends, health, movements, habitat use, foraging ecology, response to recovery activities, distribution, and movements throughout their ranges.

Out of the more than 30 active research permits, some include behavioral observations, counting/surveying, photo-identification, and capture and restraint (by hand, net, cage, or board), for the purposes of performing the following procedures:

- Collection of:
  - Blood
  - Clipped hair
  - Urine and feces
  - Nasal and oral swabs
  - Vibrissae (pulled)
  - Skin, blubber, or muscle biopsies
  - Weight and body measurements
- Injection of sedative
- Administration of drugs (intramuscular, subcutaneous, or topical)
- Attachment of instruments to hair or flippers, including flipper tagging
- Ultrasound

Some permits include incidental harassment of non-target sea lions and seals during the course of performing the permitted activities. Activities may cause stress to individual sea lions and seals; however, in most cases, harassment is not expected to rise to the level where injury or mortality is expected to occur. Nonetheless, unintentional mortality could occur and has been authorized.

5.9.3 Research effects on Salmonids

Research Effects: Although they have never been identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids. For the year 2017, NMFS issued several section 10(a)(1)(A) and section 4(d) scientific research permits and authorizations allowing lethal and non-lethal take of listed salmon. Actual take levels associated with these activities are almost certain to be a good deal lower than the authorized levels. There are two reasons for this. First, most researchers do not handle or kill the full number of juveniles (or adults) they are allowed. Our research tracking system reveals that for the past five years researchers, on average, ended up taking approximately only 33 percent of the number of juvenile salmonids and 31 percent of the adults they requested and the actual mortality was only 9 percent of requested for juveniles and 2 percent for adults. Second, the estimates of mortality for each proposed study are purposefully inflated to account for potential accidental deaths, and it is therefore very likely that fewer fish, especially juveniles, would be killed during any given research project than the researchers are allotted, in some cases many fewer.

In 2015 and 2016, NMFS consulted on the effects of fisheries research conducted and funded by the SWFSC and NWFSC, the issuance of a LOA under the MMPA for the incidental take of marine mammals pursuant to those research activities, and the issuance of scientific research permits under the ESA for directed take of ESA-listed salmonids (NMFS 2015a; NMFS 2016c). NMFS determined that the SWFSC and NWFSC fisheries research are not likely to jeopardize the continued existence of ESA-listed salmon, steelhead, or green sturgeon. For the salmonids considered in this biological opinion, NMFS expected that a total of 122 Chinook, 28 chum, 62 coho, and 24 sockeye would be incidentally captured and killed in SWFSC and NWFSC surveys.

Table 51. Take Authorized for Research in the SWFSC and NWFSC Biological Opinions.

Species and Listing Unit	Life Stage	Total Take	Lethal Take
Puget Sound Chinook	Adult	1,495	46
	Juvenile	18,052	1,192
Lower Columbia River Chinook	Adult	40	18
	Juvenile	4	4
Upper Willamette River Chinook	Adult	29	15
	Juvenile	2	2
Upper Columbia River Spring-run Chinook	Adult	9	9
	Juvenile	4	4
Snake River Fall-run Chinook	Adult	26	14
	Juvenile	1	1
Snake River Spring/summer-run Chinook	Adult	13	9
	Juvenile	3	3
Columbia River chum	Adult	9	9
	Juvenile	5	5
Hood Canal Summer-run chum	Adult	9	9
	Juvenile	285	11
Lower Columbia River coho	Adult	49	49
	Juvenile	13	13
Ozette Lake sockeye	Adult	8	8
	Juvenile	4	4
Snake River sockeye	Adult	8	8

5.9.4 Research effects on Green Sturgeon

Although they have never been identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed green sturgeon. For the year 2017, NMFS issued several section 10(a)(1)(A) and section 4(d) scientific research permits and authorizations allowing lethal and non-lethal take of listed green sturgeon. Actual take levels associated with these activities are very likely to be a good deal lower than the authorized levels. There are two reasons for this. First, most researchers do not handle or kill the full number of juveniles (or adults) they are allowed. Our research tracking system reveals that for the past five years researchers, on average, ended up taking approximately only 3 percent of the number of juvenile sturgeon and 2 percent of the adults they requested and the actual mortality was only 4 percent of requested for juveniles while no adults were killed. Second, the estimates of mortality for each proposed study are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer fish - especially juveniles - would be killed during any given research project than the researchers are allotted, in some cases many fewer.In 2015 and 2016, NMFS consulted on the effects of fisheries research conducted and funded by the SWFSC and NWFSC, the issuance of a LOA under the MMPA for the incidental take of marine mammals pursuant to those research activities, and the issuance of scientific research permits under the ESA for directed take of ESA-listed salmonids (NMFS 2015a; NMFS 2016c). NMFS determined that the SWFSC and NWFSC fisheries research are not likely to jeopardize the continued existence of ESA-listed salmon, steelhead, or green sturgeon. NMFS expected that a total of 7 adult green sturgeon would be incidentally captured with no mortalities in SWFSC and NWFSC surveys.

5.10 Oil and Gas Development

Offshore oil and gas development in Alaska poses a number of threats to listed marine species, including increased ocean noise, risk of hydrocarbon spills, production of waste liquids, habitat alteration, increased vessel traffic, and risk of ship strike. NMFS reviewed the potential effects of oil and gas development in a Final Environmental Impact Statement for the effects of oil and gas activities in the Arctic Ocean (NMFS 2013b). NMFS has conducted numerous Section 7 consultations on oil and gas activities (available at https://alaskafisheries.noaa.gov/pr/biological-opinions/)

Geophysical seismic survey activity has been described as one of the loudest man-made underwater noise sources, with the potential to harass or harm marine mammals (Richardson et al. 1995a). Controlled-source, deep-penetration reflection seismology, similar to sonar and echolocation, is the primary tool used for onshore and offshore oil exploration (Smith et al. 2017). Seismic surveys are conducted by towing long arrays of sensors affixed to wires at approximately 10 knots behind large vessels following a survey grid. High power air cannons are fired below the water surface, and the sound waves propagate through the water and miles into the seafloor. When those soundwaves encounter strong impedance contrasts (e.g., between water and the ocean floor, or between different densities of substrates), a reflection signal is detected by the sensors. Those signals can be interpreted to determine the stratigraphy of the substrate and identify oil and gas deposits.

Seismic surveying has acoustic impacts on the marine environment. The noise generated from seismic surveys has been linked to behavioral disturbance of wildlife, masking of cetacean communication, and potential auditory injury in the marine environment (Smith et al. 2017)

Seismic surveys are often accompanied by test drilling. Test drilling involves fewer direct impacts than seismic exploration, but the potential risks of test drilling, such as oil spills, may have broader consequences (Smith et al. 2017).

Oil and gas exploration, including seismic surveys and test drilling, occur within the action area and across the ranges of many of the species considered in this Biological Opinion. The vast majority of oil and gas exploration and development in Alaska occurs in the CSBSRA. Oil and gas development also occurs within Cook Inlet in the GOARA.

Information about current lease sales in Alaska is available from the Bureau of Ocean Energy Management at https://www.boem.gov/.

5.11 Pollutants and Discharges

The Clean Water Act of 1972 (CWA) has several sections or programs applicable to activities in offshore waters. Section 402 of the CWA authorizes the U.S. Environmental Protection Agency (EPA) to administer the National Pollutant Discharge Elimination System (NPDES) permit program to regulate point source discharges into waters of the United States. Section 403 of the CWA requires that EPA conduct an ocean discharge criteria evaluation for discharges of pollutants from point sources into the territorial seas, contiguous zones, and the oceans. The Ocean Discharge Criteria (40 CFR Part 125, Subpart M) sets forth specific determinations of unreasonable degradation that must be made before permits may be issued.

The EPA issued a NPDES vessel general permit that authorizes several types of discharges incidental to the normal operation of vessels, such as grey water, black water, coolant, bilge water, ballast, and deck wash (EPA (U.S. Environmental Protection Agency) 2013). The permit applies to owners and operators of non-recreational vessels that are at least 24 m (79 ft) in length, as well as to owners and operators of commercial vessels less than 24 m that discharge ballast water.

The U.S. Coast Guard has regulations related to pollution prevention and discharges from vessels carrying oil, noxious liquid substances, garbage, municipal or commercial waste, and ballast water (33 CFR Part 151). The State of Alaska regulates water quality standards within three miles of the shore.

Previous development and discharges in portions of the action area are the source of multiple pollutants that may be bioavailable (i.e., may be taken up and absorbed by animals) to ESA-listed species or their prey items (NMFS 2013b).

NMFS conducted Section 7 consultation on the effects of activities associated with the Alaska Federal/State Preparedness Plan for Response to Oil & Hazardous Substance Discharge/Releases (Unified Plan)(NMFS 2015b). The Unified Plan Biological Opinion includes a detailed review of oil and other hazardous materials spills in Alaska marine waters from 1995-2012. Although the historical spill record does not give direct information about future spills, it does help identify high risk areas and shows that spills have occurred throughout the marine waters of Alaska, but primarily in coastal, nearshore areas (Figure 28).

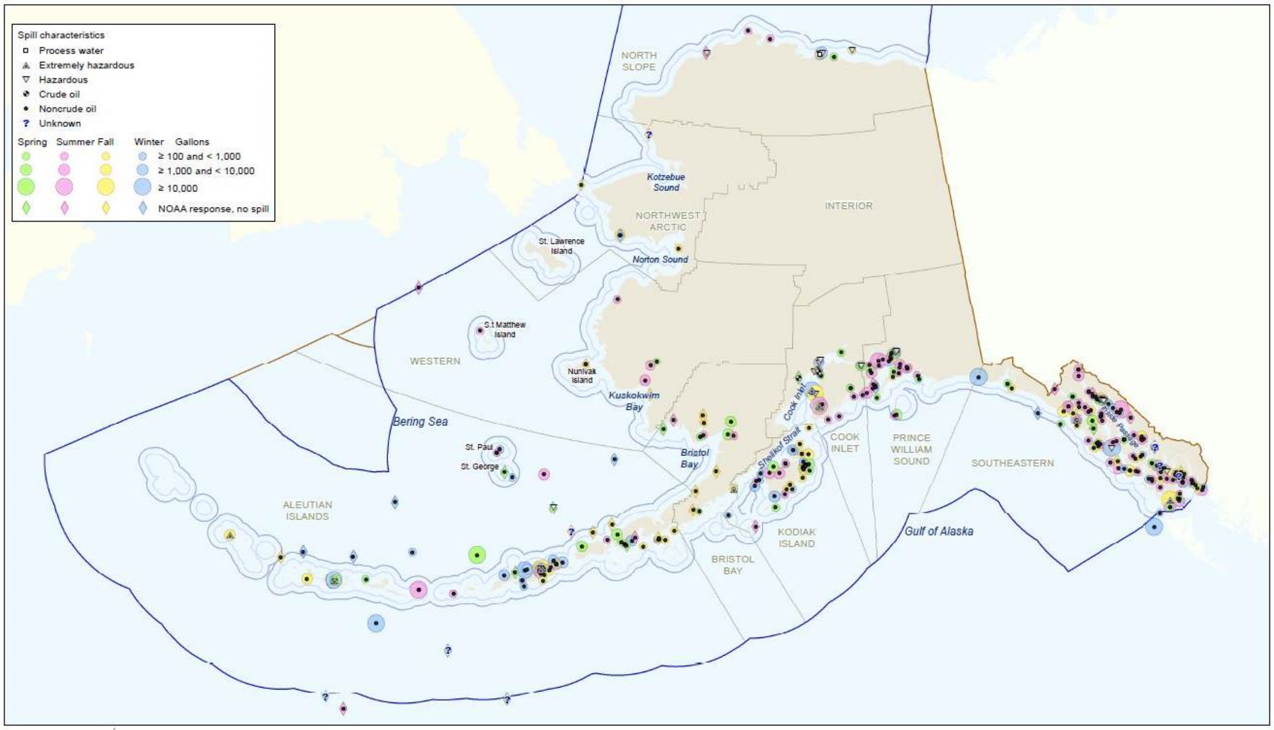

Figure 28. Hazardous materials spills reported in Alaska marine waters from 1995-2012 (adapted from a figure created by Windward Environmental, LLC for the Unified Plan BA, 2012.)

Southeast Alaska was the region in the state with the greatest number of reported oil and other hazardous substance spills in marine waters between 1995 and 2012. However, the greatest volume of spills during this same time period occurred in the Aleutian Islands region. The Northwest Arctic and Western Alaska regions reported very few spills >100 gallons (2 and 6, respectively), likely due to a lack of reporting, low human population density, and lack of major development. Cook Inlet is the only region to report crude oil spills during the 1995-2012 time period.

5.12 Military Operations

Military operations are another potential source of behavioral and habitat disturbance, injury, and mortality. The Department of Defense conducts joint training exercises with the Departments of Navy, Army, Air Force, and Coast Guard in the Joint Pacific Alaska Range Complex between April and October. The training area of concern to marine mammals is the Temporary Maritime Activities Area (TMAA) that encompasses 42,146 square nm (145,458 km^2) in the GOARA (Figure 29). The TMAA is south of Prince William Sound and east of Kodiak Island, is oriented northwest to southeast, and is approximately 300 nm long by 156 nm wide. Most Navy training activities occur in this area. Training activities occurring in the TMAA include Anti-Air, Anti-Surface, and Anti-Submarine Warfare; Naval Special Warfare; Strike Warfare, and combat and support operations that involve gunnery, bombing, sinking, and tracking exercises. Sonar, active acoustic sources, airguns, weapons firing, explosives, and vessel and aircraft noise could result in

Level A or Level B harassment of marine mammals. NMFS conducted a Section 7 consultation and prepared a biological opinion that analyzed the effects of military activities on listed species in the Gulf of Alaska (NMFS 2017c). Incidental take was authorized for seven listed species of marine mammals and several stocks of listed salmonids (Tables 44-46 in NMFS (2017c)).

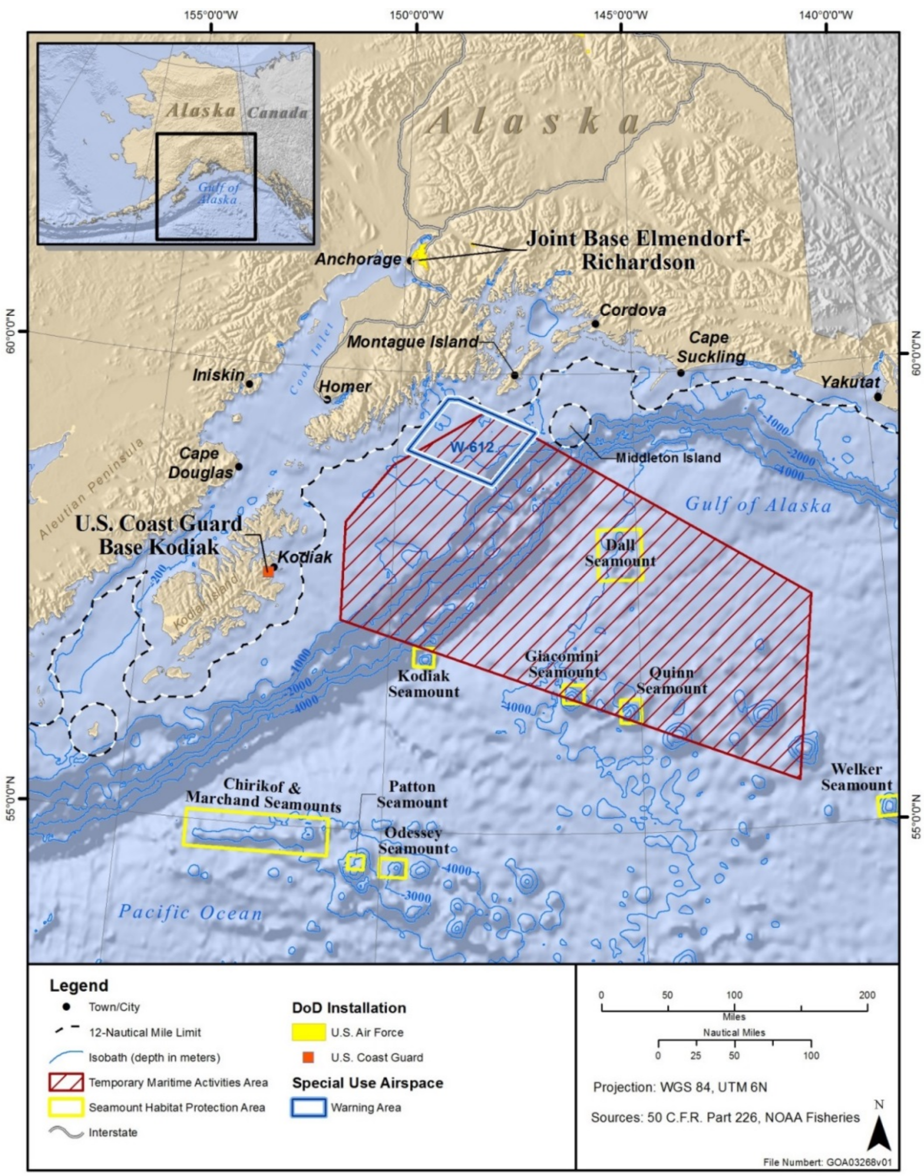

Figure 29. Temporary Maritime Activities Area (TMAA) in the Gulf of Alaska (NMFS 2017c).

6. *RESEARCH EFFECTS:* EFFECTS OF THE ACTION

"Effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

This biological opinion relies on the best scientific and commercial information available. We try to note areas of uncertainty, or situations where data is not available. In analyzing the effects of the action, NMFS gives the benefit of the doubt to the listed species by minimizing the likelihood of false negative conclusions (concluding that adverse effects are not likely when such effects are, in fact, likely to occur).

We organize our effects analysis using a stressor identification – exposure – response – risk assessment framework for the proposed activities. First, in Section 6.1 (Project Stressors and Types of Interactions), we identify which stressors are likely to affect listed species. Then, in Section 6.2 (Exposure Analysis), we estimate how many animals could be exposed to those stressors. In Section 6.3 (Response Analysis), we predict how the exposed animals will respond to those stressors. Section 8 (Integration and Synthesis) integrates information presented in Section 4 (Rangewide Status of the Species and Critical Habitat) and Section 5 (Environmental Baseline) of this opinion with the results of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species and designated critical habitat.

6.1 Project Stressors and Types of Interactions

Based on our review of the Biological Assessment (NMFS 2017b), the IHA application (NMFS 2017f), the proposed rule for issuing the IHA (83 FR 37638; August 1, 2018), the NEPA analysis (NMFS 2017d), personal communications, and other available literature as referenced in this opinion, our analysis recognizes that the proposed research activities in the GOARA, BSAIRA, and CSBSRA may affect listed species and critical habitat by three primary means: 1) the potential for mortality, serious injury, and non-serious injury, 2) behavioral harassment, and 3) modification of habitat. Specific stressors are listed under each category below. NMFS has considered and evaluated all potential stressors in this opinion for detailing how the action affects ESA-listed species and designated critical habitat and for determining whether the action will cause jeopardy to listed species and destruction of and adverse modification to designated critical habitat.

6.1.1 Mortality and Injury

We analyze two stressors as potential sources of mortality, serious injury, and non-serious injury:

1. entanglement of listed marine mammals and/or fish species in trawl or gillnets or hooking in longline survey gear; and
2. vessels striking listed marine mammals.

AFSC research surveys use a variety of trawl, gillnet, and longline gear and IPHC uses longline gear that have the potential to interact with listed marine mammals and fish species by two mechanisms: 1) accidental entanglement or hooking that may cause mortality and serious injury

(M&SI); and 2) accidental entanglement or hooking that may cause non-serious injury. Marine mammals have been taken in commercial fisheries using other types of fishing gear (e.g., purse seines). This action does include research activities done by beach seine, but does not include purse seines analogous to the purse seine gear used in the commercial fishery. Because this action does not include analogous gear, NMFS does not estimate any exposure of listed species to associated mortality and serious injury for those other gear types.

All interactions between ESA-listed species and survey gear resulting in M&SI is considered an adverse effect. Mortality, serious injury, and non-serious injury are all considered Level A harassment under the MMPA, which is defined as an act that "has the potential to injure" a marine mammal (18 U.S.C. 1362(18)(A)(i)). Because there is a very fine line between the three categories (mortality and serious injury and Level A harassment) and insufficient data exist to understand the circumstances that lead to one outcome or the other after capture in fisheries research gear, a Level A harassment could easily have been a serious injury or mortality under a slightly different set of circumstances and vice versa. So, this opinion combines non-serious injury and M&SI as Level A harassment for the five-year authorization period under the MMPA. All interactions between ESA-listed species and survey gear resulting in mortality, serious injury, or non-serious injury are considered an adverse effect.

In addition, when the area of vessel operation overlaps with the distribution of marine mammals, there is the potential for vessels to strike them. Strikes can result in either injury or mortality to marine mammals. Entanglement and vessel strikes are analyzed in detail in the exposure analysis that follows.

6.1.2 Behavioral Harassment

The MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which 1) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or 2) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B harassment) (section 3 of the MMPA; 18 U.S.C. 1362(18)(A)).

While the ESA does not define "harass," NMFS recently issued guidance interpreting the term "harass" under the ESA as a means to: "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (Wieting 2016).

We analyze the following stressors as potential sources of behavioral harassment:

1. sound fields produced by impulsive noise sources used during surveys, including echosounders, net sounders, and side scan sonar;
2. sound fields produced by continuous noise sources including survey vessels; and

3. terrestrial disturbance from the physical presence of researchers near hauled out marine mammals.

NMFS anticipates that exposures to listed species from continuous and impulsive noise sources and physical presence associated with the proposed action may result in disturbance; however, no mortalities, injuries, or permanent impairment to hearing is expected.

6.1.3 Acoustic Thresholds

Since 1997, NMFS has used generic sound exposure thresholds to determine whether an activity produces underwater and in-air sounds that might result in impacts to marine mammals (70 FR 1871, 1872; January 11, 2005). NMFS recently revised the comprehensive guidance on sound levels likely to cause injury to marine mammals through onset of permanent and temporary threshold shifts (PTS and TTS; Level A harassment) (83 FR 28824; June 21, 2018).NMFS is in the process of developing guidance for behavioral disruption (Level B harassment). However, until such guidance is available, NMFS uses the following conservative thresholds of underwater sound pressure levels[30], expressed in root mean square[31] (rms), from broadband sounds that cause behavioral disturbance, and referred to as Level B harassment under section 3(18)(A)(ii) of the MMPA:

- impulsive sound: 160 dB re 1 μPa_{rms}
- continuous sound: 120 dB re 1μPa_{rms}

Under the PTS/TTS Technical Guidance, NMFS uses the thresholds in Table 52 for underwater sounds that cause injury, referred to as Level A harassment under section 3(18)(A)(i) of the MMPA (NMFS 2016g). These acoustic thresholds are presented using dual metrics of cumulative sound exposure level (L_E) and peak sound level (PK) for impulsive sounds and L_E for non-impulsive sounds:

Table 52. Acoustic thresholds for onset of PTS for Level A Harassment (NMFS 2016g)

Hearing Group	PTS Onset Acoustic Thresholds* (Received Level)	
	Impulsive	Non-impulsive
Low-Frequency (LF) Cetaceans	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	$L_{E,LF,24h}$: 199 dB
Mid-Frequency (MF) Cetaceans	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	$L_{E,MF,24h}$: 198 dB
High-Frequency (HF) Cetaceans	$L_{pk,flat}$: 202 dB $L_{E,HF,24h}$: 155 dB	$L_{E,HF,24h}$: 173 dB
Phocid Pinnipeds (PW) (Underwater)	$L_{pk,flat}$: 218 dB $L_{E,PW,24h}$: 185 dB	$L_{E,PW,24h}$: 201 dB

[30] Sound pressure is the sound force per unit micropascals (μPa), where 1 pascal (Pa) is the pressure resulting from a force of one newton exerted over an area of one square meter. Sound pressure level is expressed as the ratio of a measured sound pressure and a reference level. The commonly used reference pressure level in acoustics is 1 μPa, and the units for underwater sound pressure levels are decibels (dB) re 1 μPa.
[31] Root mean square (rms) is the square root of the arithmetic average of the squared instantaneous pressure values.

Hearing Group	PTS Onset Acoustic Thresholds* (Received Level)	
	Impulsive	**Non-impulsive**
Otariid Pinnipeds (OW) (Underwater)	$L_{pk,flat}$: 232 dB $L_{E,OW,24h}$: 203 dB	$L_{E,OW,24h}$: 219 dB
* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered. Note: Peak sound pressure (L_{pk}) has a reference value of 1 µPa, and cumulative sound exposure level (L_E) has a reference value of 1µPa^{2}s. The subscript "flat" is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function (LF, MF, and HF cetaceans, and PW and OW pinnipeds) and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.		

6.1.4 Changes to Habitat

We analyze the following stressors that may cause changes to marine mammal habitat:

- changes in food availability due to removal of prey by research survey gear;
- changes in water quality and turbidity because of seafloor disturbance from bottom trawls or other research gear; and
- contamination from discharges and unauthorized spills.

6.1.5 Stressors Not Likely to Adversely Affect ESA-listed Species

NMFS has considered all potential stressors in this opinion detailing how the action affects ESA-listed species and designated critical habitat. The stressors listed above that are likely to adversely affect any of the ESA-listed species or designated critical habitat are analyzed in Section 6.2 (Exposure Analysis). This section discusses stressors that are not likely to adversely affect any of the ESA-listed species or designated critical habitat included in this opinion. These conditions may occur due to the research activities associated with this project, but are not likely to result in harassment and rise to the level of a take under the ESA. These stressors are briefly described below before the opinion analyzes other stressors in more detail.

Table 53. Anticipated effects from four stressors.

Stressor	Anticipated Effects from that stressor
Research activities not likely to interact with ESA-listed species	The effects are discountable due to the lack of overlap between stressor and listed species
Acoustic disturbance from sound fields produced by continuous noise sources including vessels	The effects are likely to be insignificant due to the transient and temporary nature of the noise and the implementation of avoidance mitigation measures.

Stressor	Anticipated Effects from that stressor
Changes in water quality and turbidity because of seafloor disturbance from bottom trawls or other research gear	The effects are expected to be too small to detect and therefore insignificant to ESA-listed species and critical habitat.
Contamination from discharges and unauthorized spills	The effects are extremely unlikely to occur because of the standard operating procedures and mitigation measures associated with the action, and so is discountable or otherwise insignificant.

6.1.5.1 Research activities that are not expected to interact with ESA-listed species

The AFSC and IPHC are requesting incidental takes of ESA-listed marine mammals and fish in trawl nets, longline gear, and gillnet gear. These use of these types of gear in research activities and/or the use of analogous gear in commercial fisheries has resulted in mortality or serious injury of marine mammal species. Other gear listed in Table 54 is much smaller, under direct human observation and control, and has not resulted in any observed injuries or mortalities to listed species, and NMFS does not expect that these research activities will result in any injuries or mortalities to listed species in the future. Research activities using these kinds of equipment are not expected to result in Level A harassment, serious injury, mortality, or even non-serious injuries with ESA-listed species. Based on the best available information, NMFS concludes that effects from the research activites listed in Table 54 will be discountable and are not expected to result in take of ESA-listed marine mammals or fish species. No take caused by these activities is authorized in this opinion.

Table 54. Equipment used to conduct research activities by AFSC and IPHC that is not expected to interact with ESA-listed species.

Gear used in AFSC research activities	Gear used in IPHC research activities
• Various echosounders and sonars (used only for navigation) • CTD profilers (used to sample the water column) • Drop cameras • Towed cameras/AUVs/ROVs • Various plankton nets • Continuous water samplers • Video camera sleds/beam trawls • Fish pots/holding pens • SCUBA divers • VR2 passive acoustic receivers • Beach seines and pole seines • Predator exclusion cages • Benthic settling plates • Fyke nets • Epibenthic tow sleds • Electro-fishing gear • Remote PIT detectors • Water quality instruments	• Various echosounders and sonars (used only for navigation) • CTD profilers (used to sample the water column) • Drop cameras • Towed cameras

AFSC is also requesting take in the form of Level B harassment for marine mammals due to acoustic noise and terrestrial disturbance, but no harassment of ESA-listed fish species is anticipated by those stressors. IPHC research activities only take marine mammals and fish by interaction with longline gear. IPHC research activities do not use acoustic gear and do not come within 3nm of rookeries, so exposure to those stressors is not analyzed for IPHC activities.

6.1.5.2 Acoustic disturbance from sound fields produced by continuous noise sources including vessels

Vessel noise associated with research surveys will be transmitted through water and constitutes a continuous noise source. NMFS anticipates that whenever noise is produced from vessel operations, it may overlap with listed species and that some individuals are likely to be exposed to these continuous noise sources.

Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Kipple and Gabriele 2007; McKenna et al. 2012; Richardson et al. 1995b). Broadband source levels for small vessels have been measured at 145 to 170 dB re: 1 µPa, and broadband source levels for small ships and supply vessels 55-85m in length have been measured at 170 to 180 dB re: 1µPa (Richardson 1995). Vessels used in the research activities of this opinion are within these size classes (Table 64) and likely emit similar levels of continuous noise.

Exposure of ESA-listed species to continuous vessel noise may occur. However, it is unlikely to rise to the level of take due to the temporary and transient nature of vessel noise; habituation of ESA-listed species to the presence of vessel noise; and avoidance and mitigation measures associated with the action, which includes the NMFS humpback whale approach regulations, the NMFS code of conduct, and the “move on” rule. Any effects to listed species would be too small to detect or measure, and therefore insignificant. Based on the best available information, NMFS concludes that continuous vessel noise is not expected to result in take of ESA-listed marine mammals or fish species.

Changes in Water Quality and Turbidity

Survey gear that comes in contact with the ocean floor, such as bottom trawls, longline gear, and sediment samplers, may cause short-term changes in water quality and turbidity through displacement of sediment. Longline gear and sediment samplers are expected to have minimal effects on water quality and turbidity. Of the gear types used by the AFSC and IPHC, bottom trawl gear is expected to have the largest effect on substrates and create the most suspended sediment that could affect water quality and turbidity.

The effects of the trawl footprint were analyzed in section 4.2 of the EA for this action (NMFS 2017). In general, the duration of bottom trawls conducted by the AFSC are short (15-30 min.), and the trawl openings are relatively small (< 20 m compared to up to 90 m in commercial trawls), to minimize the amount seafloor and sediment disturbed. Table 4.2-2 of the EA summarizes the maximum number of bottom trawls and the area disturbed in a year by AFSC survey efforts. If all bottom-contact trawl surveys in the action area were deployed every year, they would disturb approximately 114 square miles across the three research areas, or an estimated 0.08% of the action area, and potentially result in temporary increased turbidity. As suspended sediments and particulates are expected to dissipate quickly (within hours), no long-term effects on water quality are expected to occur in the action area as the result of the proposed action. Any effects to ESA-listed marine mammals and fish species from elevated turbidities or changes in water quality would be too small to detect or measure, given small scale and the temporary nature of any effects from survey gear, and thus any such effects would be insignificant.

Based on the best available information, NMFS concludes that changes in water quality and turbidity are not expected to result in take of ESA-listed marine mammals or fish species.

6.1.5.3 Risk of Contamination from Oil Spill and/or contaminants

Discharge from vessels can include sewage, ballast water, fuel, oil, miscellaneous chemicals, garbage, and plastics. Short-term effects on ESA-listed marine mammal and fish species may occur if a small amount of petroleum or other contaminants accidentally spill into ocean waters from vessels during research activities.

Potentially adverse effects resulting from discharge of contaminants from vessels used during research surveys are possible, but unlikely. If such effects were to occur, they would be infrequent, temporary, small-scale, and localized. All NOAA and IPHC ocean-going vessels are subject to the regulations of MARPOL 73/78, the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978. MARPOL includes six Annexes that cover discharge of oil, noxious liquid substances, harmful packaged substances, sewage, garbage, and air pollution (International Maritime Organization (IMO) 2010). Adherence to these regulations minimizes or eliminates the likelihood of discharges of potentially harmful substances into the marine environment. Annex V specifically prohibits plastic disposal anywhere at sea and severely restricts discharge of other garbage (IMO 2010). NOAA vessels and vessels contracted for the performance of AFSC fisheries and ecosystem research activities are fully equipped to respond to emergencies, including fuel spills, and crew receive extensive safety and emergency response training. Additionally, AFSC and IPHC survey vessels do not refuel at sea. These precautionary measures help reduce the likelihood of fuel spills and increase the ability of survey vessels to manage and quickly contain fuel spills. Oil spill prevention training and equipment may be more variable on small boats and contracted fishing vessels used in research, although all vessels are required to comply with USCG regulations on spills. Potential effects on the physical environment resulting from discharged or spilled materials are not gear type dependent and would be negligible to minor throughout the AFSC research areas.

A consequential discharge of contaminants from research vessels is possible, but unlikely due to standard operating practices designed to avoid such discharges. Assuming normal vessel activities, the potential volume of petroleum hydrocarbons and other contaminants from any such discharge is expected to be small and localized and exposure of ESA-listed species is extremely unlikely. If listed species were exposed, effects from such a small discharge would likely be short-term and too small to detect or measure. Therefore any such effects would be insignificant and discountable.

Based on the best available information, NMFS concludes that oil spills and/or contaminants are not expected to result in take of ESA-listed marine mammals or fish species.

6.1.6 Stressors Likely to Adversely Affect ESA-listed Species

NMFS anticipates that the following stressors are likely to adversely affect the listed species and designated critical habitat included in this opinion:

- Entanglement in trawl and gillnets and hooking in longline survey gear;
- Acoustic disturbance from sound fields produced by impulsive noise sources including echosounders, net sounders, and side scan sonar; and
- Terrestrial disturbance from the physical presence of researchers.

These stressors and the nature and magnitude of that exposure to species and critical habitat are discussed further in Section 6.2 (Exposure Analysis) below.

NMFS analyzed two additional stressors:

- changes in food availability due to research survey removal of prey and discards; and
- risk of vessels striking marine mammals.

Impacts to listed species are evaluated in Section 6.2 (Exposure Analysis), but exposure does not rise to the level of take.

6.1.7 Interrelated/Interdependent Actions

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 C.F.R. § 402.02). NMFS did not identify any interrelated or interdependent actions associated with this project.

6.2 Exposure Analysis

As discussed in Section 3 (Approach to the Assessment), exposure analyses are designed to identify the listed resources that are likely to co-occur with these effects in space and time and the nature of that co-occurrence. In this step of our analysis, we try to identify the number, age (or life stage), and sex of the individuals that are likely to be exposed to an action’s effects and the populations or subpopulations those individuals represent.

6.2.1 Effects of mitigation on exposure estimates

The AFSC and IPHC have developed and implemented mitigation measures to reduce interactions between their research activities and ESA-listed marine mammals and fish species as described in the *Mitigation Measures* section of this opinion. NMFS expects that these mitigation measures will minimize exposure of ESA-listed species to stressors associated with this action. We discuss how these measures mitigate impacts of each stressor as the stressor is analyzed in this section. Mitigation measures are focused on reducing impacts to marine mammal species. None are included specifically to address impacts to ESA-listed fish species.

Mitigation measures are designed to limit impacts to protected species and apply to all research activities analyzed in this opinion, including NMFS vessels, chartered and contract vessels, IPHC vessels. Current contract provisions for chartered vessels require both pre-cruise briefings that include directions on how to implement mitigation measures, and post-cruise briefings that include discussions of any interactions with marine mammals or perceived problems.

6.2.2 Exposure to Gear Interaction

The types of research gear used by AFSC and IPHC were described previously under Section 2.1 *Proposed Action.* Here, we anticipate potential exposure of marine mammals to gear types with potential for interaction, including trawls, longlines, and gillnets. Table 1, Table 2, and Table 3 provide detailed information describing each survey’s level of activity, location, and gear type.

Which Listed Species and Critical Habitats may be exposed?

The location and timing of the fishing effort, the type of gear, the speed of the vessel, and the duration of the tow or longline set, among other variables, all influence the nature of interactions between fishing gear and ESA-listed species. Below we review how listed species interact with the types of gear used in AFSC and IPHC research activities and use the historical record and other methods to estimate exposure to the listed species most likely to interact with fishing gear. Any sex or age class of those species could interact with fishing gear.

6.2.2.1 Interactions between marine mammals and trawl gear

Trawl nets are towed nets (i.e., active fishing) consisting of a cone-shaped net with a codend or bag for collecting the fish and can be designed to fish at the bottom, surface, or any other depth in the water column. Marine mammals have the potential to be caught in bottom, surface, mid-water, and beam trawl nets (NMFS 2017c). These nets are used in groundfish assessments throughout Alaska annually during all seasons (Tables 1-3). The tows are conducted at a variety of depths depending on the research target species, from near the surface down to the bottom, during all hours of the day, using charter vessels or NOAA vessels. From 2004 through 2015, AFSC towed at least 1,250 tows per year using these trawl nets, and only four marine mammals were captured and killed during this period, all in the Gulf of Alaska. These mortalities included two Dall's porpoise captured in midwater and surface trawls, one northern fur seal captured in a bottom trawl, and a sea otter in a Nordic 264 surface trawl (Table 56, Figure 30).

The AFSC predicts that about the same number of tows will be deployed using these nets in the foreseeable future, as has been in previous research activities. Given the timing and geographic scope of its trawl surveys, all age classes of marine mammals are at risk of interaction.

Mitigation Measures for Listed Marine Mammals During Research with Trawl Gear

If a marine mammal or other protected species is at risk from a research activity before setting gear or when occupying the site, then the research activity will stop until the animal moves away and is no longer at risk. If the animal does not move from the research site, then the research activity must be moved to an alternate location or canceled so there is no longer a risk to the animal or other protected species. If a protected species is encountered during a research activity when gear is deployed, then the vessel shall maintain course, slow down, or take other actions to avoid direct contact of the animal with the vessel or gear.

If marine mammals are observed at or near the sampling station, the Chief Scientist (Lead Sampler) and the vessel captain will determine the best strategy to avoid potential takes based on the species encountered; their numbers, behaviors, positions, and vectors relative to the vessel; and other factors.

After moving on, if marine mammals are still visible from the vessel and appear to be at risk, the Chief Scientist (Lead Sampler) may decide, in consultation with the vessel captain, to move again or to skip sampling at the station. In many cases, the survey design can accommodate sampling at an alternate site. In most cases, trawl gear is not deployed if marine mammals have been observed from the ship during approach to the station unless those animals do not appear to be in danger of interactions with the trawl.

Standard bottom trawl survey tow durations are 15-30 minutes or less at a targeted depth, excluding deployment and retrieval time. These short durations reduce the likelihood of attracting and incidentally taking protected species. The resulting tow distances are typically 1 to 2 nautical miles (nm) (1.9 to 3.7 kilometers [km]), depending on the survey and trawl speed. Some trawl gear, such as the FOCI midwater tows, may take one hour to retrieve.

6.2.2.2 Interactions between fish species and trawl gear

Salmonids

The primary effect of the proposed research on the ESA-listed fish species will be in the form of capturing and unintentionally killing fish, primarily in trawl gear. Deployment of fishing gear by the AFSC results in capture for many fish; some of these are retained on board and others are discarded either dead or alive. However, many fish likely escape initial capture. This can be due to mesh size constraints, swimming ability, or tissue tears related to hooking; the sub-lethal effects on these fish are difficult to analyze because they remain free-swimming and therefore cannot be observed for long-term effects. For the purposes of our analysis, most fish brought on board are assumed to have died. Direct mortality of fish occurs as a result of various AFSC fisheries research activities. Fish are caught in a variety of gear types, some of which involve experimental tests of fishing gear and equipment designed to reduce incidental catch of non-target species or protected species. These surveys provide important data to determine biomass estimates, reproductive potential, and distribution of fish stocks in waters off Alaska, which are necessary for fisheries managers to maintain healthy populations and rebuild overfished or depressed stocks. The AFSC also conducts surveys to provide indices of juvenile abundance that are used to identify and characterize the strength of year classes before fish are large enough to be harvested by commercial or recreational fisheries off Alaska. Stock assessments based on accurate abundance and distribution data are essential to developing effective management strategies for groundfish and salmon stocks originating in Alaska.

Southern DPS Green Sturgeon

The North Pacific Groundfish Observer Program, which observes federal groundfish fisheries off Alaska within the Action Area, has recorded rare encounters with green sturgeon in trawl fisheries in the Bering Sea for over three decades (NMFS 2015e). It is unknown whether these green sturgeon belonged to the Northern DPS or the Southern DPS. However, it follows that given the reduced scale of the research surveys as compared to the commercial fisheries that encounters with sturgeon would be even less likely in the research program. In fact, during the same three decade period there have been no takes of green sturgeon reported from any of the fishery surveys considered in the Proposed Action.

6.2.2.3 Interactions between marine mammals and gillnet gear

Gillnets consist of vertical netting held in place by floats and weights to selectively target fish of uniform size depending on the netting size (Walden 1996). Gillnets are either anchored to the bottom ('set gillnet') or are deployed with one end attached to a vessel and is allowed to drift with the current or tides ('drift gillnet'). The AFSC uses gillnets of various mesh sizes and 35 to 150 ft in length in forage fish and salmon studies.

Marine mammals have the potential to be caught in gillnet gear. Depending on the gillnet mesh size, animals can become entangled around their necks, mouths, flippers, tails, or entire body. Entanglement can prevent proper feeding, constrict growth, or cause infection. Marine mammals entangled in set gillnets can drown while those entangled in drift gillnets can drag gear for miles as they migrate and forage, leading to extreme fatigue or injury. As discussed in the baseline section, listed species are taken in commercial gillnet gear.

The AFSC predicts that about the same amount of effort will be deployed using gillnets in the foreseeable future, as has been in previous research activities. Given the timing and geographic scope of its surveys, any age class of listed species may be taken.

Mitigation Measures for Listed Marine Mammals During Research with Gillnet Gear

Gillnets are not deployed if marine mammals are observed on arrival at the sample site. The exception is for animals that because of their behavior, travel vector, or other factors do not appear to be at risk of interaction with the gillnet gear.

If no marine mammals are present at the sampling location, the gear is set and continuously monitored during the soak. If a marine mammal is observed during the soak and appears to be at risk of interaction with the gear, then the gear is pulled immediately.

6.2.2.4 Interactions between marine mammals and longline gear

Longlines are basically strings of baited hooks that are either anchored to the bottom, for targeting groundfish, or are free-floating, for targeting pelagic species. Longlines represent a passive fishing technique. Any longline generally consists of a mainline from which leader lines (gangions) with baited hooks branch off at a specified interval, and is left to passively fish, or soak, for a set period of time before the vessel returns to retrieve the gear.

Marine mammals may be hooked or entangled in longline gear, with interactions potentially resulting in death due to drowning, strangulation, severing of carotid arteries or the esophagus, infection, an inability to evade predators, or starvation due to an inability to catch prey (Hofmeyr et al. 2002), although it is more likely that animals will survive being hooked if they are able to reach the surface to breathe. Injuries can include lacerations and puncture wounds. Animals may attempt to depredate either bait or catch, with subsequent hooking, or may become accidentally entangled. Hooking injuries and ingested gear are most common in small cetaceans and pinnipeds, but have been observed in large cetaceans (e.g., sperm whales).

Interactions have not been documented between marine mammals and AFSC longline research gear. Steller sea lions have previously been caught in the Gulf of Alaska Pacific cod longline fishery and have been caught on IPHC longline survey gear. Sperm whales in the GOA are commonly attracted to longline fishing operations and have learned how to remove fish from longline gear as it is retrieved. Although no sperm whales have been hooked on IPHC or AFSC longline survey gear, they have been hooked on similar commercial fisheries gear (Muto et al. 2017).

Mitigation Measures for Listed Marine Mammals During Research with Longline Gear

Current mitigation measures include weighting the longlines so that they sink faster, reducing the time available to mammal depredation during setting events; employing a ‘move on’ policy if whales or pinnipeds are spotted prior to setting or hauling research gear; and requirements when whales are interacting with the gear to stop hauling gear, return it to the seafloor, and either wait until the whales leave or move to a nearby sampling station. To date, IPHC research has not had a take of a whale. Additionally, whale avoidance measures are intended to reduce habituation of whales to depredating longline gear, thereby reducing interactions. IPHC research survey standardization requires that gear may only be set after 5 a.m. or first light, whichever is later, and which may reduce the likelihood that visual predators such as pinnipeds are taken by the gear because they can more likely be seen and avoided by the vessel crew. Mitigation measures are discussed in greater detail in Section 2.1.5.

The move-on rule may be implemented if listed species are present near the vessel and appear to be at risk of interactions with the longline gear; longline sets are not initiated if marine mammals are detected and at risk of a potential interaction with the gear. The location of the sampling station may be altered to avoid potentially adverse interactions with marine mammals. If, just prior to setting the longline gear, marine mammals are sighted in the area and are considered to be at risk of interaction with the research gear then the sampling station is delayed, moved, or canceled.

The IPHC’s Fishery-independent Setline Survey uses bottom longline gear with total mainline length ranging from 1.65 to 4.5 kilometers long. This total length is made up of three to ten skates with each skate measuring 1,800 feet long. Up to four sets are made in the morning, if no whales are present, and the longline gear soaks for five hours before haul-back begins.

To reduce depredation and habituation of whales if they begin to depredate or in cases when known depredating species (such as killer and sperm whales) are present, AFSC and IPHC research boats are instructed to sink the line back down to the seafloor and travel to and haul gear on a different station set that morning, returning to the station where the whales were later the same day. If whales remain in the vicinity for extended periods or are present on a day’s last remaining station, the only practical way to minimize depredation if whales find the vessel is to continue retrieving the gear as quickly as possible.

AFSC and IPHC longline survey protocols specifically prohibit chumming before or during the longline setting operations (i.e., releasing additional bait to attract target species to the gear). However, longline surveys are conducted on contracted commercial fishing catcher vessels and fish are processed as the longline is retrieved. Spent bait and processing offal are discarded away from the longline retrieval area, which often serves to attract marine mammals away from the longline. Due to the volume of fish caught with each set and the length of time it takes to retrieve the longline, the retention of spent bait and offal until the gear is completely retrieved is not possible.

6.2.2.5 Approach to estimating exposure to gear interaction

Marine Mammals

Large whales (e.g., fin, humpback, sei, sperm, killer whales) have been caught in commercial fisheries trawl, longline, pot, and gillnet gear, as well as recreational and unknown sources of gear. Humpback whales interact with commercial and recreational pot and gillnet gear while feeding in nearshore waters in summer months, as discussed in the Baseline section. However, there have been very few recorded interactions between research activities and pinniped and cetacean species, as discussed in the Baseline section. The mitigation measures used during the research activities likely reduce interactions between the survey gear and marine mammals. In the case of trawl gear, the lower interaction rate is likely further reduced because the research gear is much smaller than the commercial gear. Currently only two AFSC surveys use gillnet gear in small, localized projects as described in Table 1. Both projects are closely monitored and use very small nets (Table 55).

Table 55. General characteristics of research activities and commercial fisheries that use trawl and gillnet gear.

Characteristic	Commercial Fisheries	Research Activities
Spatial Extent	Targets important fishing grounds which may also have higher concentrations of marine mammals	Annual summer bottom trawl surveys are based on a stratified random sampling design and cover a vast area of the Gulf of Alaska and eastern Bering Sea
Trawl tow duration	15 minutes - hours	15 - 30 minutes
Trawl gear size	mouth openings < 90 meters	mouth openings < 20 meters
Gillnet length	900-1,800 feet	350 - 150 feet

Though the pots used for research work are different than those used in recreational and commercial fishing, humpbacks can get caught in the vertical line to the pot, which is present regardless of what size or kind of pot to which it is attached. There is a very small amount of pot gear effort in research activities, described in Table 1.

In addition to the move-on rule and other mitigation measures, NMFS expects that these differences in gear size (trawl and gillnet) and the total amount of fishing effort (short soak times and small numbers of gillnets and pots) reduce the risk of interactions between cetaceans and trawl, pot, and gillnet gear to a discountable level. Thus, we estimate zero take of cetaceans due to entangelment with trawl, pot, and gillnet gear.

The longline gear used during the AFSC longline survey and the IPHC Setline survey is similar to commercial gear. Because sperm whales have interacted with commercial fisheries longline gear, we estimate exposure for sperm whales below. Humpback whales have interacted with commercial longline gear, but at a very low rate of interaction. Between 2007 and 2016, longline comprised between 1 and 2% of all reported humpback entanglements. AFSC's longline survey takes place on the outer shelf and slope in the GOA. The IPHC longline survey does occur in inside waters of southeast Alaska and nearshore waters around Kodiak where humpback whales feed in summer months. However the very low historical interaction rate (between research activities and humpback whales) combined with the move-on rule and other mitigation measures reduce the risk of interaction between humpback whales and longline gear to a discountable level. Thus, we estimate zero take of all cetaceans except for sperm whales due to interactions with longline gear.

Pinnipeds have been taken by commercial gear and by research activities, so we include ringed and bearded seals and Steller sea lions in our analysis below.

Effects to designated critical habitat are not analyzed because NMFS does not expect that entanglement will affect any of the PBFs of designated critical habitat.

Because AFSC and IPHC research surveys have interacted with few marine mammals in the past, historical catch from research surveys alone was insufficient to analyze potential exposures for all listed species. The following data sources and associated methods were used to estimate exposure of each listed marine mammal species to mortality or serious injury from AFSC and/or IPHC research activities:

1. Historical catch of that species during research surveys
2. Historical catch of analogous species during research surveys
3. Historical catch of that species with similar gear in a commercial fishery conducted in the same area as the survey
4. Historical catch of that species with similar gear in a commercial fishery conducted in a different area from the survey
5. Spatial-temporal overlap of that species' distribution with historical or planned research activities

We used Method 1 to estimate exposure whenever possible. If the data to support using that method was not available, we used Method 2, etc. In a case where different estimates were possible with differnet methods, we used the worst case scenario that generated the highest estimate of take.

Method 1

Estimating potential takes based on historical interactions of marine mammals with AFSC and IPHC research gear (Method 1) was considered the most direct approach. Because interactions have been so rare in the past, NMFS chose to use the longest dataset possible that reflects current research activities (2004 – 2017 for AFSC research and 1998 – 2017 for IPHC research). Whenever available, those data were used to estimate exposures in this analysis. It is anticipated that all species that interacted with AFSC and IPHC research gear historically could potentially be taken in the future. NMFS considered all historic marine mammal interactions with AFSC (Table 56 and Figure 30) and IPHC (Table 57 and Figure 29) to calculate the total expected exposure into the foreseeable future.

If no interactions between a marine mammal and the research activity appeared in the historical record, then the other data sources were used to estimate exposure. The estimated exposures for each species and the method used to make the estimates are presented in Table 61 at the end of this section, and represent the best prediction informed by these various sources. Note that all of the historical takes from both AFSC and IPHC research effort in Alaska waters have occurred in the GOARA (Figure 30).

Table 56. Historical Injury and Mortality/Level A takes of marine mammals during AFSC surveys from 2004 through 2017

Survey Name	Species Taken	Gear Type	Date (Time) Taken	# Killed	# Released Alive[1]	Total Taken
2011						
Gulf Project –Upper Trophic Level[2]	Dall's porpoise	Cantrawl Surface Trawl	21 September (07:41)	1	0	1
			10 September (16:25)	1	0	1
2009						
Gulf of Alaska Biennial Shelf and Slope Bottom Trawl Groundfish	Northern fur seal (Eastern Pacific stock)	Bottom trawl	13 June (18:23)	1	0	1
2008						
Southeast Alaska Coastal Monitoring	Northern sea otter[3]	Nordic 264 Surface Trawl	23 August (19:30)	1	0	1

Survey Name	Species Taken	Gear Type	Date (Time) Taken	# Killed	# Released Alive[1]	Total Taken
TOTAL				**4**	**0**	**4**

1. Serious injury determinations were not previously made for animals released alive, but will be part of standard protocols for released animals after such incidental takes are authorized and will be reported in Stock Assessment Reports.
2. Survey reduced in scope and renamed the "Gulf of Alaska Assessment"
3. Based on location, take was most likely from the Southeast Alaska DPS.

Table 57. Historic Injury and Mortality/Level A takes of marine mammals during IPHC fishery-independent setline surveys in U.S. waters 1998-2017

Year	Date	Species Taken	# Killed	Latitude	Longitude	Depth (m)
1999	7/17/1999	Harbor Seal	1	44.1665	-124.9	128
2003	7/23/2003	Steller Sea Lion	1	56.833	-135.866	182
2007	7/16/2007	Steller Sea Lion	1	55.3333	-134.312	184
2011	7/31/2011	Harbor Seal	1	45.3325	-124.416	357
2016	7/22/2016	Steller Sea Lion	1	58.3332	-138.433	129

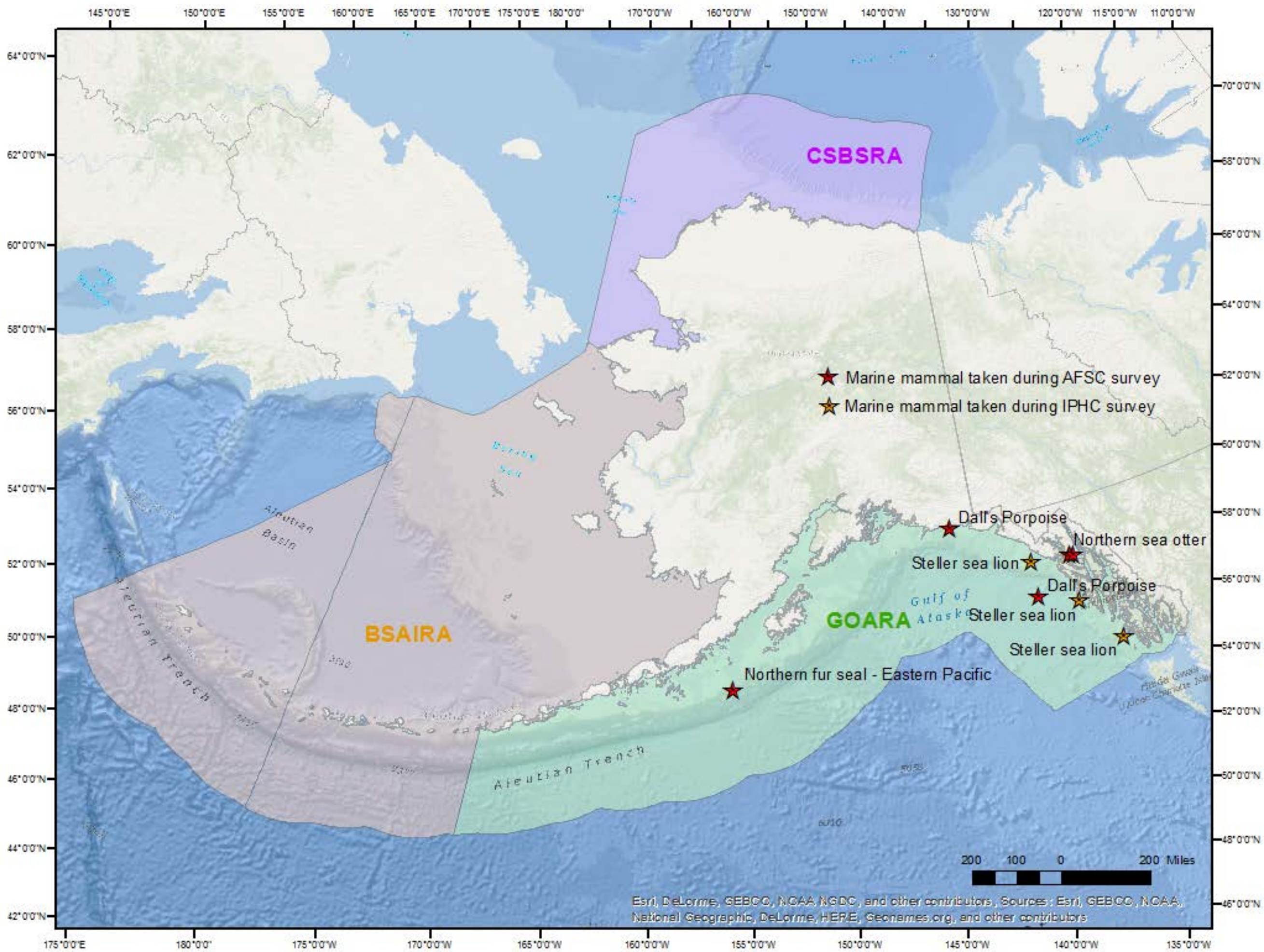

Figure 30. Locations of species taken historically on IPHC fishery-independent setline surveys in U.S. waters 1998-2017 and locations of species taken historically during AFSC surveys from 2004-2017. Details provided in Table 56 and Table 57.

AFSC activities

While Dall's porpoise, northern sea otter, and Northern fur seal (Eastern Pacific stock) have been taken historically in AFSC research activities, no takes of ESA-listed marine mammal species have been documented during AFSC research activities. Therefore, the other methods (2-5) of estimating exposure will be used for these activities, which is discussed below.

IPHC activities

Three Steller sea lions have been caught in the IPHC research surveys in the GOA between 1998 and 2017 (Table 57 and Figure 30). It is unknown whether the individuals were from the eastern or western DPS. Because this area is used by both the eastern and western DPS of Steller sea lions (NMFS 2013f), NMFS assumes that individuals from the Western DPS are vulnerable to IPHC survey gear. The highest number of Western DPS Steller sea lions caught in any year was one individual. As a conservative approach, NMFS estimates that one individual would be taken in research survey gear in each of the five years of research activities associated with the LOA and similarly into the foreseeable future. Because those individuals could be from either the Eastern or Western DPS and because no information is available to estimate the percentage of each, NMFS conservatively assumes that all of the Steller sea lions caught on survey gear are from the Western DPS.

Method 2

A number of factors were taken into account to determine whether ESA-listed marine mammal species may have a similar vulnerability to fisheries research gear (e.g., density, abundance, behavior, feeding ecology, travel in groups, prior interactions with similar gear in other NMFS Fisheries Science Center research) as analogous species. The annual exposure estimates for the listed species are set equal to the maximum number of interactions annually between research gear and the analogous species from 2004-2017. In Method 2, western DPS Steller sea lion were considered analogous to northern fur seal and therefore deemed to have a similar vulnerability to trawl gear.

AFSC activities

There have been no documented interactions of ESA-listed marine mammal species with AFSC research trawl gear; however, interaction with non ESA-listed marine mammals have been documented in the GOARA. Over the 2004-2017 period, AFSC research trawls interacted with two Dall's porpoise and one northern fur seal (Table 56). The AFSC interaction rates in the GOARA have exhibited some inter-annual variation in numbers, possibly due to changing marine mammal densities and distributions and dynamic oceanographic conditions. Occurrences of multiple marine mammals being caught per year during survey operations are possible, as in 2011, but are rare. There have been no marine mammal interactions with AFSC bottom trawls in the BSAIRA and CSBSRA.

The exposure estimates were determined by rounding the annual average take for a particular species up to the nearest whole number (to reflect a value that was representative of an entire animal) and multiplying by five to account for the 5-year authorization period. For example, if a species interacted with AFSC mid-water trawl gear 0.2 times per year, on average, this number was rounded up to one and then multiplied by five to determine a take request of five. Based on past experience, the AFSC expects there to be some variability in the actual number of annual gear interactions. By using an average based approach, it is expected to capture the variability that may occur on an annual basis over the period of PR1's authorization. Because we estimate that one northern fur seal will be exposed per year based on historical interactions, we also estimate that one Western DPS Steller sea lion will be exposed per year (five total over the 5-year authorization period) due to this analogy estimation process. We expect these same levels of interactions to occur into the foreseeable future.

IPHC activities

This method was not used to estimate Level A harassment of listed species due to IPHC research activities because no analogous species have been taken by IPHC research activities. Exposure of Steller sea lions was calculated using Method 1, discussed previously, and other species' exposures are discussed in Methods 3 and 4.

Method 3

NMFS also used marine mammal interactions with commercial fishing gear to estimate exposure. Several gear types used during AFSC fisheries research surveys are similar to those used in commercial fishing operations in Alaska, including bottom, mid-water, and surface trawls; small beach seines; hook-and-line gear; longlines; gillnets; and pots/traps. However, it is important to note that even though AFSC uses similar types of gear as that in commercial fisheries, the size, configuration, and methods of use of this gear during AFSC research surveys differs significantly than that used in commercial operations and in ways that reduce the likelihood of incidental catch of ESA-listed species.

For example, the annual summer bottom trawl surveys are based on a stratified random or systematic sampling designs and cover a vast area of the Gulf of Alaska and eastern Bering Sea. Tows are of short duration between 15 and 30 minutes, and the survey does not deliberately target important fishing grounds, which may also have higher concentrations of marine mammals. The mouth openings of the research bottom trawls are less than 20 m, while the openings of commercial trawls can range up to 295 ft (90 m). The duration of commercial tows can be as short as 15 minutes, but can often last for an hour to many hours.

Species taken in commercial fisheries (NMFS 2016d) that were deemed similar to research surveys were considered to have a higher probability of exposure to AFSC and IPHC research gear. That probability was based on an evaluation of the similarities and differences in the timing, spatial footprint relative to species distribution, and operational details of the commercial fisheries and the research activities.

NMFS does not expect interactions between the large whales included in this opinion and surveys using trawls or gillnets because AFSC research gear and fishing methodology is not analogous to that used in commercial fisheries known to have taken large cetaceans (e.g., fin, humpback, sei, sperm, killer whales).

Marine mammals have been taken in commercial fisheries using other types of fishing gear (e.g., purse seines). While this action includes research activities by beach seine, it does not include purse seines analogous to the purse seine gear used in the commercial fishery. Because this action does not include analogous gear, NMFS does not estimate any exposure of listed species to associated mortality and serious injury for those other gear types.

AFSC and IPHC activities

Commercial fisheries' interactions with Steller sea lions in the GOARA and BSAIRA are modified by various protection measures put in place to reduce competition for prey and other stressors, as reviewed in the Environmental Baseline. These measures include spatial and temporal restrictions on commercial fisheries. Using direct interactions between commercial fisheries and Steller sea lions as a prediction for what might occur during research activities that are not subject to the same area and time restrictions is problematic; however, this action does include mitigation measures that provide buffer zones around rookeries and haulouts (though smaller than the ones to which commercial fisheries are subject) and operational procedures that NMFS expects are likely to substantially reduce direct interactions, particularly during the breeding and pupping season.

Western DPS Steller sea lions have been taken in the following commercial fisheries: GOA Pacific cod trawl, GOA pollock trawl, GOA Pacific cod longline, Prince William Sound salmon set gillnet, and BSAI Pacific cod longline. Exposure estimates of Western DPS Steller sea lion are estimated using Method 2, above. NMFS estimates one exposure over the five-year period from AFSC research longline surveys in the GOARA and one in the BSAIRA based on analogy to the GOA Pacific cod longline fishery and the BSAI Pacific cod longline fishery; and NMFS estimates one exposure over the five-year period from the Prince William Sound gillnet survey by analogy to the salmon set gillnet fishery. We expect similar levels of interactions to continue into the foreseeable future.

Sperm whales interact with longline gear as described earlier. Although five sperm whales have been seriously injured between 2010 and 2014 in the GOA sablefish long line commercial fishery (Helker et al. 2015), there have been no reports of sperm or killer whales ever being taken on AFSC longline surveys or IPHC fishery-independent setline surveys or by the Pacific halibut fishery within the last 5 years. The probability of large whale interactions with research activities is likely reduced by the much lower level of survey effort and duration relative to that of commercial fisheries. Data on commercial fishing effort (i.e., total length of longlines, numbers of hooks deployed, buoy lines, and soak times) are not publicly available, and we know of no other proxies for effort that could be compared to research activities. IPHC research effort takes a very small amount of fish when compared to commercial fisheries. However, because sperm whales do interact with AFSC sablefish research longlines and because of the recent GOA sablefish longline observations described above, NMFS estimates that one sperm whale will directly interact with longline research activities by the AFSC and an additional whale will likely interact with longline research activities by the IPHC over the five year period. NMFS assumes this level of direct interaction with the AFSC longline research activities (one sperm whale per every five years) and with the IPHC longline research activities (one sperm whale per every five years) will continue into the foreseeable future.

No additional exposures of listed species to mortality and serious injury were calculated using this method.

Method 4

IPHC activities

IPHC research gear could be considered analogous to commercial longline fishing gear that may be used in areas other than where surveys are conducted (e.g., Garrison 2007; Roche et al. 2007). The Alaska Pacific cod longline fishery has taken one Western DPS Steller sea lion and one ringed seal. The IPHC requested that PR1 authorize a single take over the five-year period for ringed seal (AK stock) based on Method 4. Exposure of Western DPS Steller sea lion was calculated previously using Methods 1, 2, and 3.

Method 5

BSAIRA

In the BSAI, there is potential for a rare incidental take due to physical presence of marine mammals within the area where AFSC conducts research. NMFS estimates that one ringed seal and one bearded seal may be exposed to research trawls in the BSAIRA over the five-year period of authorization due to spatial-temporal overlap with research activities. Because Western DPS Steller sea lions are caught in GOA commercial trawl fisheries and we have already estimated exposure by analogy to northern fur seals caught in AFSC research trawls in the GOARA, NMFS estimates the additional exposure of one Western DPS Steller sea lion per year (five over the five-year PR1 authorization period) due to trawl research surveys in the BSAIRA, consistent with the exposure estimate in the GOARA. We expect similar levels of interactions to continue into the foreseeable future for ringed seals and bearded seals (one interaction per species over five years) and for Western DPS Steller sea lion (one interaction per year) in the BSAIRA.

CSBSRA

Because there has been no historic incidental catch in fisheries research in the Chukchi Sea/Beaufort Sea Research Area and because commercial fisheries have not been authorized in the Chukchi Sea/Beaufort Sea Research Area, it was not possible to use the "by analogy" process employed above to inform possible incidental take of marine mammals in fisheries research activities for this region. Therefore the potential for this type of take was evaluated by examining the areas of overlap between proposed fisheries research activities and the distribution of marine mammal species endemic to the area. This analysis considered the seasonality of the fisheries research activities and the species distributions, as well as other factors that may influence the degree of potential overlap such as sea and shorefast ice occurrence. AFSC fisheries research typically avoids working in areas where sea ice is present.

NMFS estimates the take of one ringed seal and one bearded seal in fisheries research trawl surveys in the CSBSRA over the five-year authorization period. We expect similar levels of interactions to continue into the foreseeable future.

GOARA

In Cook Inlet, IPHC research surveys have not been conducted north of 59° 50'N; however, within the next five years, the IPHC plans to extend its survey grid northward to just south of East Foreland in Cook Inlet for a single year. This is within Cook Inlet Beluga Whale Critical Habitat (76 FR 20180, April 11, 2011) (Figure 31).

The IPHC considered that beluga whales show behavior similar to large dolphins and porpoises, which have been taken elsewhere in longline fisheries. Nevertheless, the IPHC indicates the likelihood of a take of a beluga whale to be extremely low because there are no records of belugas being taken by any longline gear in research surveys or commercial fisheries. In addition, the beluga whale population is concentrated north of East Foreland during the summer months when IPHC conducts its research surveys (Shelden et al. 2013) and north of planned survey stations, therefore NMFS does not estimate any Level A harassment (from gear interaction) to Cook Inlet Belugas from IPHC longline research activities in Cook Inlet, and no Level A take is authorized in this opinion.

Salmonids

Information describing the incidental capture of salmonids (ESA listed and non-listedoriginating from the West Coast Region) during recent AFSC trawl surveys has been provided in the AFSC's Draft Environmental Assessment and Biological Assessment (Table 58). Detailed descriptions of the individual surveys can be found in those documents. ESA-listed salmon affected by AFSC research projects may be caught and unintentionally killed during the following annual surveys:

- Chukchi Sea Trawl Survey
- Bering Sea Bottom Trawl Survey
- Bering Arctic Subarctic Integrated Survey
- Aleutian Islands Bottom Trawl Survey
- Alaska Longline Surveys
- Gulf of Alaska Assessment Survey
- Gulf of Alaska Bottom Trawl Survey
- ADFG Trawl Survey of Gulf of Alaska and Eastern Aleutian Islands
- Southeast Alaska Coastal Monitoring
- International Halibut Commission Halibut Surveys

Table 58. Total number of salmon (ESA-listed and non-listed) caught during AFSC, ADFG, and IPHC surveys conducted in the Chukchi Sea, Bering Sea, Aleutian Islands, and Gulf of Alaska (2011−2016).

Survey	Chinook	Chum	Coho	Sockeye
Chukchi Sea Study	461	-	1	28
Bering Sea Bottom Trawl	8	94	-	6
Bering Arctic Subarctic Integrated Survey – Northern Portion	1,988	12,815	467	1,236
Bering Arctic Subarctic Integrated Survey – Southern Portion	191	1,719	280	9,944
Aleutian Islands Bottom Trawl	4	52	-	-
Alaska Longline Surveys	-	1	172	-
Gulf of Alaska Assessment	1,619	12,645	9,106	15,175
Gulf of Alaska Bottom Trawl	103	545	47	2
ADFG Trawl Surveys	5	95	-	-
Southeast Alaska Coastal Monitoring	149	37,765	7,901	8,749
Halibut Surveys (longline)	14	-	90	14

We cannot readily distinguish between the proportion of juvenile, sub-adult, and adult salmonids that were incidentally captured in AFSC, ADFG, and IPHC surveys. Survival from the juvenile to sub-adult and sub-adult to adult life stages is relatively low, and there are far more juveniles in the population than sub-adults and more sub-adults than adults. In the absence of data to indicate otherwise, we will treat each unintentional mortality as if it were an adult salmonid.

In order to estimate the amount of salmon that may be captured during future surveys, we examine the record of the total number of salmon caught over the years 2011–2016 (Table 58).

The AFSC, ADFG, and IPHC surveys capture salmon from the Chukchi Sea to the Gulf of Alaska. The Bering Arctic Subarctic Integrated Survey, Gulf of Alaska Assessment, and Southeast Alaska Coastal Monitoring projects target salmon, as well as other species. Out of the total number of salmon captured by all surveys, 87% of the Chinook, 99% of chum, 98% of coho, and nearly 100% of sockeye are captured by these three projects.

While the numbers reported in Table A represent the totals for the various species of salmon, only a portion of these totals are likely to be ESA-listed fish. The AFSC used several steps to estimate a total for salmon (ESA-listed and non-listed) originating from Washington, Oregon, and Idaho. The AFSC's step-wise process of elimination is described in the BA, and includes age-specific analysis, genetic stock composition analysis, and comparison of abundance estimates from Alaska, British Columbia, and the Pacific Northwest. Using these methods, the BA estimates that 908 Chinook, 10,763 chum, 1,728 coho, and 7,072 sockeye salmon originating from the Pacific Northwest were captured and killed in the AFSC, ADFG, and IPHC surveys between the years 2011-2016 (Table 59).

Table 59. Total number of salmon originating from the Pacific Northwest caught during AFSC, ADFG, and IPHC surveys conducted in the Chukchi Sea, Bering Sea, Aleutian Islands, and Gulf of Alaska (2011-2016).

Survey	Chinook	Chum	Coho	Sockeye
Chukchi Sea Study	69	0	1	3
Bering Sea Bottom Trawl	2	24		1
Bering Arctic Subarctic Integrated Survey – Northern Portion	273	0	230	55
Bering Arctic Subarctic Integrated Survey – Southern Portion	10	161	100	472
Aleutian Islands Bottom Trawl	4	52	0	0
Alaska Longline Surveys	0	1	172	0
Gulf of Alaska Assessment	378	8,537	823	147
Gulf of Alaska Bottom Trawl	33	480	47	2
ADFG Trawl Surveys	0	0	0	0
Southeast Alaska Coastal Monitoring	2	997	237	262
Halibut Surveys (longline)	14	0	90	14

The total catch of salmon in AFSC, ADFG, and IPHC surveys, originating from the Pacific Northwest, can be further reduced by dividing the catch by the number of surveys per year. Some surveys are conducted yearly while others are conducted every other year. Therefore, to look at the catch per species per year by survey taking into account the frequency of the survey, the total catch per species was divided by the number of surveys that have been conducted during 2011-2016, resulting in a standardized average catch by species per year per survey. The totals in Table 60 are the AFSC's estimated number of salmon originating from the Pacific Northwest that may be caught and killed on an annual basis for each survey.

Table 60. Annual number of salmon originating from the Pacific Northwest caught during AFSC, ADFG, and IPHC surveys conducted in the Chukchi Sea, Bering Sea, Aleutian Islands, and Gulf of Alaska (2011-2016).

Survey	Chinook	Chum	Coho	Sockeye
Chukchi Sea Study	23	0	1	1
Bering Sea Bottom Trawl	1	4	0	1
Bering Arctic Subarctic Integrated Survey – Northern Sites	91	0	77	18
Bering Arctic Subarctic Integrated Survey – Southern Sites	2	27	17	79
Aleutian Islands Bottom Trawl	2	18	0	0
Alaska Longline Surveys	0	1	29	0
Gulf of Alaska Assessment	63	1,423	137	25
Gulf of Alaska Bottom Trawl	11	160	16	1
ADFG Trawl Surveys	0	0	0	0
Southeast Alaska Coastal Monitoring	1	166	39	43
Halibut Surveys (longline)	3	0	15	20
Total	**197**	**1,799**	**331**	**188**

The totals in Table 60 represent estimates for Chinook, coho, chum, and sockeye salmon originating from the Pacific Northwest. The AFSC estimates that they may annually take of listed and unlisted salmonids up to 197 Chinook, 1,799 chum, 331 coho, and 188 sockeye salmon originating from the Puget Sound, Washington coast, and Columbia River basin.

Southern DPS Green Sturgeon

Based on the overall scale of the AFSC research program as compared to commercial fisheries and the rarity of the species in Alaska waters, it is highly unlikely that the proposed research program will result in take of ESA-listed green sturgeon. The proposed action will have no effect on critical habitat for the ESA-listed green sturgeon, since it occurs in California, well outside the action area. It is unlikely that the proposed AFSC research program will result in the take of any green sturgeon from either the listed or non-listed DPS. However, the known offshore distribution of subadult and adult green sturgeon overlaps with the action area, and the species has been taken in commercial fisheries with gear types similar to the AFSC research in GOA (as reported in (NMFS 2015c). Therefore, to be precautionary, NMFS estimates that one non-lethal take of ESA-listed green sturgeon may occur as a result of AFSC activities over the five year period, using the fishery analogy Method 3, described above. We expect similar levels of interactions (one take of Southern DPS Green Sturgeon every five years) to continue into the foreseeable future.

6.2.2.5.1 Summary of potential exposure to Gear Interactions

Marine Mammals

Using the multiple methods detailed above, NMFS expects the marine mammals in Table 61 will likely be exposed to Level A harassment from interactions with gear during AFSC and IPHC research activities over the next five years. Because there have been no historical catches in research surveys or commercial fisheries of other cetacean species included in this opinion, NMFS does not expect interactions with listed species other than those listed below. Designated critical habitat is not analyzed for this stressor due to the nature of the interaction (meaning, gear interaction is not likely to impact designated critical habitat).

Table 61. Estimated injury, serious injury, and/or mortality for five-year period

Agency	AFSC						IPHC	Total
Area	GOA			BSAI		CSBS	GOA/BSAI	
Gear type	Trawl	Longline	Gillnet	Trawl	Longline	Trawl	Longline	
Steller sea lion (Western DPS)	5[2]	1[3]	1[3]	5[3]	1[3]	-	5[1]	18 + 5[6] (23 total)
Bearded seal	-	-	-	1[5]	-	1[5]	-	2
Ringed seal	-	-	-	1[5]	1[3]	1[5]	1[4]	4
Sperm whale (North Pacific)	-	1[3]	-	-	-	-	1[3]	2

1-Historical catch of that species during research surveys
2-Historical catch of analogous species during research surveys
3-Historical catch of that species with similar gear in a commercial fishery in the same area
4-Historical catch of that species with similar gear in a commercial fishery conducted elsewhere
5-Spatial-temporal overlap of that species' distribution with historical or planned research activities
6-Six pinnipeds are estimated to be taken of an undetermined species. 5 of them are anticipated to be taken within the georgraphic distribution of western DPS Steller sea lion, and so NMFS conservatively estimates all 5 are western DPS Steller sea lion.

Salmonids

There are multiple ESA-listed ESUs of Chinook salmon, one listed coho salmon ESU, two listed chum salmon ESUs, and two listed sockeye salmon ESUs. In addition to the ESA-listed ESUs, there are multiple non-listed ESUs in the Puget Sound, Washington coast, and Columbia Basin. We do not know what proportion of the take will be from the ESA-listed ESUs. However, we can compare the abundance of listed ESUs to non-listed ESUs and use the proportions to estimate the total take for each listed ESU. Using annual escapement estimates from WDFW, ODFW, and IDFG we can determine what proportion of the total are likely to be from ESA-listed Chinook, coho, chum, and sockeye salmon. Adult escapement estimates for the Puget Sound and Washington coast are summarized in WDFW's Salmonid Stock Inventory (http://wdfw.wa.gov/conservation/fisheries/sasi/) and adult escapement estimates for the Columbia Basin are summarized in the Joint Staff Reports (http://wdfw.wa.gov/fishing/crc/staff_reports.html). Average adult escapement estimates for

ESA-listed salmon are reported in the Status of the Species section. The five-year average adult escapement estimates for ESA-listed and non-listed Pacific Northwest salmon are summarized in Table 62 below.

Table 62. Average adult escapement of ESA-listed and non-listed Chinook, coho, chum, and sockeye salmon from the Columbia River basin, Washington coast, and Puget Sound.

Species and Listing Unit	ESA Status	Average Adult Escapement	Percent of the Total for the Species
Non-listed Chinook	Non-listed	427,068	67.0%
Puget Sound Chinook	Threatened	32,481	5.1%
Lower Columbia River Chinook	Threatened	68,061	10.7%
Upper Willamette River Chinook	Threatened	45,896	7.2%
Upper Columbia River Spring-run Chinook	Endangered	9,057	1.4%
Snake River Fall-run Chinook	Threatened	37,812	5.9%
Snake River Spring/summer-run Chinook	Threatened	17,043	2.7%
Total Chinook		***637,418***	-
Non-listed Chum	Non-listed	601,231	94.0%
Hood Canal Summer-run Chum	Threatened	27,452	4.3%
Columbia River Chum	Threatened	11,070	1.7%
Total Chum		***639,753***	-
Non-listed Coho	Non-listed	1,122,217	95.2%
Lower Columbia River Coho	Threatened	56,068	4.8%
Total Coho		***1,178,285***	-
Non-listed Sockeye	Non-listed	336,172	98.9%
Snake River Sockeye	Endangered	1,373	0.4%
Ozette Lake Sockeye	Threatened	2,321	0.7%
Total Sockeye		***339,866***	-

As evident from Table 62, the vast majority (at least 67%) of salmon originating from the Columbia Basin, Washington coast, and Puget Sound are not listed under the ESA. Of the total abundance for each species, the listed stocks comprise 33% for Chinook, 6% for chum, 5% for coho, and 1% for sockeye. We do not know what proportion of the take would be from each listed salmonid. We therefore will assume that the likelihood of take is proportional to the abundance of each ESU in relation to the total PNW abundance for the species.

Table 63. Estimated take per year of unlisted and ESA-listed Chinook, coho, chum, and sockeye salmon in AFSC, ADFG, and IPHC surveys.

Species and Listing Unit	Average Adult Escapement	Total Take	Percent of Abundance
Non-listed Chinook	427,068	132	0.03%
Puget Sound Chinook	32,481	10	0.03%
Lower Columbia River Chinook	68,061	21	0.03%
Upper Willamette River Chinook	45,896	14	0.03%
Upper Columbia River Spring-run Chinook	9,057	3	0.03%
Snake River Fall-run Chinook	37,812	12	0.03%
Snake River Spring/summer-run Chinook	17,043	5	0.03%
Totals	**637,418**	**197**	**0.03%**
Non-listed Chum	601,231	1,691	0.3%
Hood Canal Summer-run Chum	27,452	77	0.3%
Columbia River Chum	11,070	31	0.3%
Totals	**639,753**	**1,799**	**0.3%**
Non-listed Coho	1,122,217	315	0.03%
Lower Columbia River Coho	56,068	16	0.03%
Totals	**1,178,285**	**331**	**0.03%**
Non-listed Sockeye	336,172	186	0.06%
Snake River Sockeye	1,373	1	0.06%
Ozette Lake Sockeye	2,321	1	0.06%
Totals	**339,866**	**188**	**0.06%**

When compared to the abundance of the ESU (Percent of Abundance), the potential mortality levels are very low: a maximum of 0.3% may be killed from any of the listed salmonids (Table 63). Furthermore, the effects from all of the research surveys are not likely to disproportionately affect any one population within each ESU. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

Southern DPS Green Sturgeon

Because of overlap in space between the action area and likely distribution of Southern DPS Green Sturgeon and the fact that Southern DPS Green Sturgeon have been taken in commercial fisheries with gear similar to the research activities analyzed in this opinion, NMFS estimates that one non-lethal take of ESA-listed green sturgeon may occur over the 5 year LOA authorization period. We expect a similar level of interaction (one take every five years) to continue into the foreseeable future.

6.2.2.6 Potential for Vessel Strike of cetaceans and pinnipeds

6.2.2.6.1 Which Listed Species and Critical Habitats may be exposed?

As discussed in *Section 5 Environmental Baseline,* vessel strikes of cetaceans and pinnipeds have been documented in the action area. NMFS anticipates all listed marine mammals are at risk for vessel strike. The vast majority of documented strikes in Alaska between 1978–2011 involved humpback whales, while strikes of fin, gray, sperm, and Cook Inlet belugas whales have also been documented (Neilson et al. 2012). Although risk of vessel strike has not been identified as a significant concern for Steller sea lions (Loughlin and York 2000), the Recovery Plan for this species states that Steller sea lions may be more susceptible to ship strike mortality or injury in harbors or in areas where animals are concentrated (e.g., near rookeries or haulouts) (NMFS 2008). Since 2000, there have been four reported ship strikes of Steller sea lions within Alaska, as discussed in the Environmental Baseline. NMFS anticipated the effects of vessel strike on ESA-listed fish species to be discountable, and so those effects are not analyzed below. We do analyze the potential for vessel strikes of ESA-listed marine mammal species during research activities.

6.2.2.6.2 Mitigation to Prevent Vessel Strikes

AFSC and IPHC rely on both slow vessel speeds and observers watching for marine mammals to mitigate the potential of striking marine mammals while in transit and during active gear deployment and retrieval.

AFSC research vessel speeds during trawling or deploying sampling gear (other than acoustic equipment) are generally less than 5 knots. IPHC vessel speeds are less than 4 knots when research vessels are actively setting gear, and less than 2 knots when hauling gear. Because marine mammals typically can avoid slow-moving vessels, the probability of collision with a large whale or other marine mammal while gear is deployed (setting and hauling) is negligible. When transiting between sampling stations or while conducting acoustic surveys, AFSC and IPHC research vessels cruise at speeds from 6 to 13 knots, but average around 10 knots (Table 64).

In addition, research vessel captains and crew watch for marine mammals while underway and take necessary actions to avoid encounters. When research vessels are operating in areas and at times when many marine mammals have been observed or are likely to be present, additional crew members are tasked with monitoring for marine mammals. In these cases, vessel captains may also further reduce speed to improve the chances of observing and avoiding marine mammals. At any time during a survey or in transit, any bridge personnel that sights ESA-listed marine mammal species that may intersect with the vessel course will immediately communicate their presence to the helm for appropriate course alteration or speed reduction as possible to avoid incidental collisions, particularly with large whales. When transiting areas with high marine mammal activity, such as Unimak Pass and other passes in the Aleutian Islands and the Bering Strait, extra crew are often called to provide additional monitoring capability around the vessel. Additional mitigation measures will also apply when vessels are present in designated critical habitat, which will further mitigate the risk of vessel strikes of marine mammals.

Humpback Whale Approach Regulations

As part of this action, AFSC will abide by regulations intended to minimize harmful interactions between ships and humpback whales in Alaska (see 50 CFR §§ 216.18, 223.214, and 224.103(b)). These regulations require that all vessels:

- Not approach within 100 yards of a humpback whale, or cause a vessel or other object to approach within 100 yards of a humpback whale,
- Not intercept or place vessel in the path of oncoming humpback whales causing them to surface within 100 yards of vessel,
- Not disrupt the normal behavior or prior activity of a whale, and
- Operate all vessels at a slow, safe speed when near a humpback whale. Safe speed is defined in regulation (see 33 CFR § 83.06).

6.2.2.6.3 Approach to Estimating Exposures to Vessel Strike

We have already demonstrated that there is overlap in space and time between research activities and listed species' distributions in all three research areas. Because of that overlap, there is potential for vessels to strike the marine mammals along their path. A review of the vessels associated with this action, vessel characteristics historically associated with vessel strike, and an evaluation of the potential for strike from vessels conducting research activities as part of this action are presented below.

Vessel Speed

In an analysis of the probability of lethal mortality of large whales at a given speed, results of a study using a logistic regression model showed that the greatest rate of change in the probability of a lethal injury to a large whale, as a function of vessel speed, occurs between vessel speeds of 8.6 and 15 knots (Vanderlaan and Taggart 2007). Across this speed range, they found that the chances of a lethal injury decline from approximately 80 percent at 15 knots to approximately 20 percent at 8.6 knots. Notably, it is only at speeds below 11.8 knots that the chances of lethal injury drop below 50 percent and above 15 knots the chances asymptotically increase toward 100 percent.

As discussed in the Environmental Baseline section, Neilson et al. (2012) summarize 108 reported whale-vessel collisions in Alaska from 1987–2011. In reports where vessel speed at the time of collision was known, 49% were travelling at or faster than 12 knots, 31% were traveling slower than 12 knots, and 20% were anchored or drifting vessels.

Vessels used in Research Activities analyzed in this Opinion

The AFSC uses the NOAA ship R/V *Oscar Dyson*, the NOAA ship R/V *Fairweather*, and research vessels in the University National Oceanographic Laboratory (UNOLS) fleet, while the Alaska Department of Fish and Game (ADFG) uses the R/V *Resolution* to conduct fisheries research on behalf of the AFSC. However, most of the vessels used for AFSC and IPHC research activities analyzed in this opinion are chartered fishing vessels. A wide range of commercial fishing vessels participate in such research, ranging from small open boats to modern trawlers and longliners measuring up to 57 m in length. The sizes of the vessels used, engine types, cruising speeds, etc. vary depending upon the location and requirements of the research for which the vessel is used. Although some vessels are chartered on a regular basis, the particular vessels used year to year depend on availability, research needs, and competition for contract services.

The IPHC hires boats that are either commercial halibut/sablefish fishing boats or dedicated research boats that have the ability to set and haul fixed-hook demersal longline gear that is common in the Pacific halibut and sablefish fishery. During the last five years, chartered vessels have been between 56 and 100 feet in length and have included traditional halibut schooners as well as steel- and aluminum-hulled seiners that also participate in longline fisheries.

Although vessels involved in IPHC and AFSC research activities have average and top cruising speeds at or above 12 knots (Table 64), when transiting between sampling stations or while conducting acoustic surveys, AFSC and IPHC research vessels cruise at speeds from 6 to 13 knots, but average 10 knots (NMFS 2017b). When AFSC research vessels are trawling or deploying other types of sampling gear (other than acoustic equipment), vessel speeds are less than 5 knots. IPHC vessel speeds are typically less than 4 knots when actively setting gear, and less than 2 knots when hauling gear.

Table 64. Typical travel speeds associated with research vessels.

Vessel name	Length (m)	Emergency (top) Speed	Average cruising Speed from ship specifications	Cruising Speed transiting between stations	Cruising speed at survey stations
NOAA Ship *Oscar Dyson*[1]	63.6	14 knots	12 knots	10 knots	<5 knots
NOAA Ship *Fairweather*[2]	70.4	13.4 knots	12.5 knots	10 knots	<5 knots
R/V *Resolution ADF&G*	27.7	12 knots	10 knots	10 knots	<5 knots
Various chartered fishing vessels	< 57 AFSC 15-30 IPHC	Various	Various	10 knots	<5 knots for AFSC surveys 2-4 knots for IPHC surveys

[1] Information obtained at http://www.omao.noaa.gov/learn/marine-operations/ships/oscar-dyson/about/specifications
[2] Information obtained at *http://www.omao.noaa.gov/learn/marine-operations/ships/fairweather*

Effects of Vessel Strike of North Pacific right whale

Ship strikes may affect the continued existence of North Pacific right whales, an endangered species. Little is known of the nature or extent of this problem in the North Pacific (Muto et al. 2017). However, their slow swim speed and skim feeding behavior may put right whales at a high risk of collision if they were to overlap in time and space with a vessel.

North Atlantic right whales are highly vulnerable to ship collisions. North Pacific right whales cross a major Trans-Pacific shipping lane when traveling to and from the Bering Sea (e.g., Unimak Pass) (Figure 26); their probability of ship-strike mortalities may increase with the likely future opening of an ice-free Northwest Passage (Wade et al. 2011a). While no vessel collisions or prop strikes involving North Pacific right whales have been documented in the Bering Sea, because of the rarity of right whales the impact to the species from even low levels of interaction could be significant.

Research activities occur inside North Pacific right whale critical habitat in the GOARA and the BSAIRA. Though there is overlap, NMFS expects that the mitigation measures, in particular the slow vessel speeds while present in North Pacific right whale critical habitat, will diminish the risk of vessel strike to a discountable level.

Effects of Vessel Strike of Cook Inlet beluga whale

Although exact AFSC survey locations vary year to year, AFSC research only overlaps with the distribution of Cook Inlet beluga whale in the southern portion of Cook Inlet (Figure 31). IPHC research surveys have not been conducted north of 59° 50’N in the past; however, IPHC plans to extend its survey grid northward to just south of East Foreland in Cook Inlet for a single year. This is within Cook Inlet Beluga Whale Critical Habitat. Although it is highly unlikely that an IPHC fisheries research vessel would strike a Cook Inlet beluga whale due to the mitigation measures described above and the very limited spatial/temporal overlap in one survey for one year, a strike would be considered a substantial impact to the small population of this endangered species.

Beluga whales are active throughout Cook Inlet year round, however the beluga whale population is concentrated north of East Foreland during the summer months when IPHC conducts its research surveys (Shelden et al. 2013). This concentration is north of where IPHC has planned survey stations (Figure 31), therefore NMFS expects that these factors diminish the risk of vessel strike of a Cook Inlet beluga whale to a discountable level.

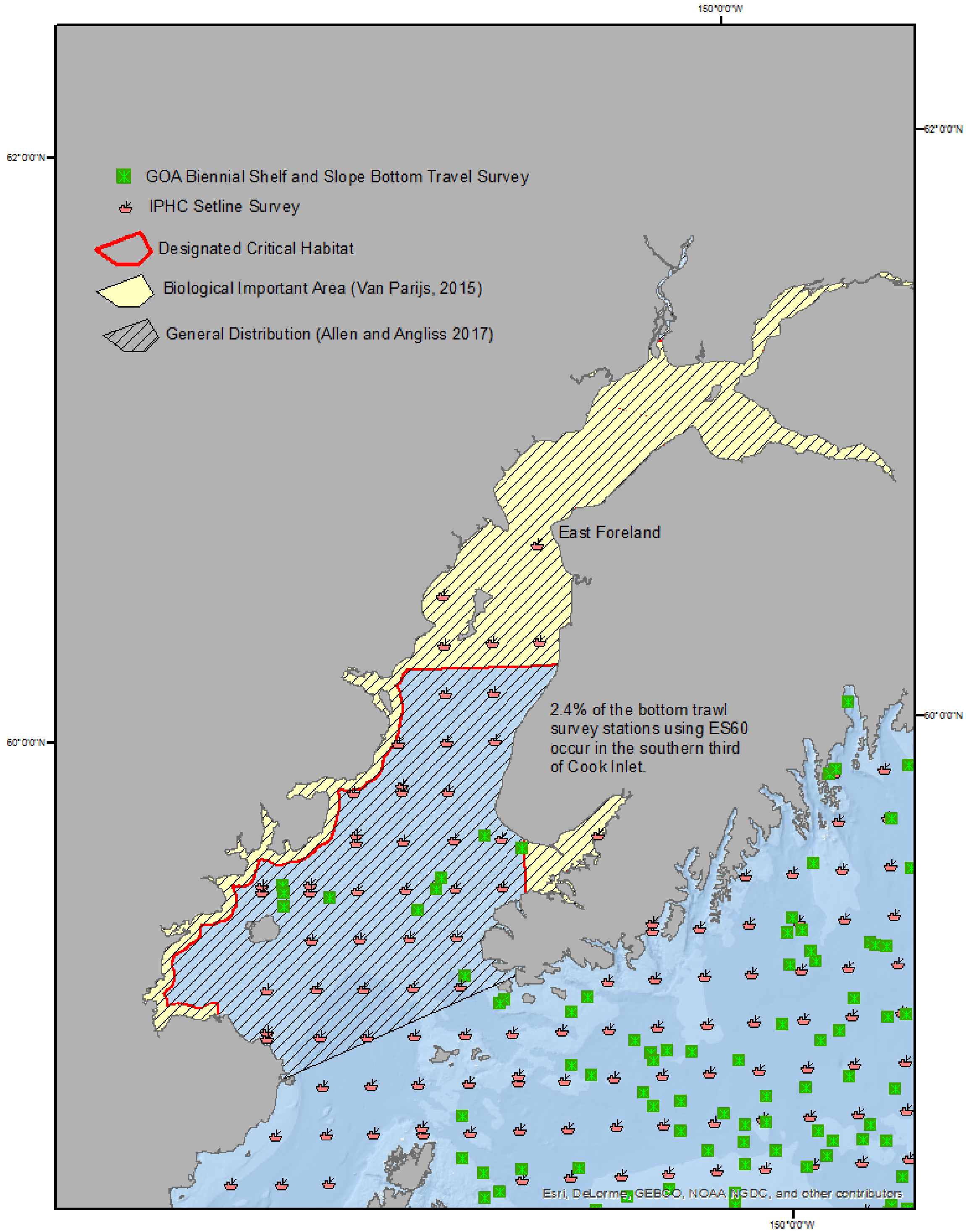

Figure 31. Overlap of research activities with Cook Inlet beluga whale distribution and critical habitat. AFSC survey stations vary annually but do not occur in critical habitat except possibly 1 station in Kachemak Bay. IPHC survey will extend north into critical habitat one time during the next 5 years.

Effects of Vessel Strike of other cetacean species

Humpback, fin, and sperm whales are broadly distributed throughout the action area during research activities and therefore are at risk of vessel strike in the GOARA and the BSAIRA. Sei whales and blue whales occur in the GOA in the summer for feeding and may be at risk in the GOARA during research activities.

AFSC research activities in the CSBSRA occur between June and September, mainly in the Chukchi Sea after bowhead whales have already travelled through the Chukchi Sea on the northward migration into the Beaufort Sea, as discussed in the *Status of the Species* section. In September and October, bowhead whales start moving back towards the Chukchi Sea on their southern migration back to the Bering Sea. AFSC research activities occur through September in the Chukchi Sea, so likely will be finishing up as bowhead whales start to move back through the Chukchi Sea. Most of the research activities in the Bering Sea in the winter and early spring months is south of 55ºN, with little overlap of bowheads during that time. Then in April and May, bowheads begin the northern migration again, which does not overlap with any research activities. There is very little potential overlap of research activities with bowhead whales, and therefore the risk of vessel strike of bowhead whales is so low that NMFS considers it to be discountable.

Effects of Vessel Strike of Ringed and Bearded Seals

Ringed seals and bearded seals are broadly distributed throughout the Bering, Chukchi, and Beaufort Seas. Seals that closely approach larger vessels also have some potential to be drawn into bow-thrusters or ducted propellers (BOEM 2011). In recent years gray and harbor seal carcasses have been found on beaches in eastern North America and Europe with injuries indicating the seals may have been drawn through ducted propellers (BOEM 2011). To date, no similar incidents have been documented in Alaska (BOEM 2011). However, Sternfeld (2004) documented a single spotted seal stranding in Bristol Bay, Alaska, that may have resulted from a propeller strike. There have been no incidents of ship strike with bearded seals or ringed seals documented in Alaska (BOEM 2011).

However, pinnipeds may be at the greatest risk from shipping threats in areas where geographic constriction concentrates seals and vessel activity into confined areas, such as the Bering Strait (Arctic Council 2009). The Bering Strait area is used by bearded seals in the early spring for whelping, nursing, and mating (from April to May) and in the late spring for molting and migrating (from May to June). The BASIS, Northern Bering Sea bottom trawl, and Arctic Ecosystem Integrated Surveys have sampling stations in the Bering Strait area, but only in the fall, so they are not present during these peak times of bearded seal use.

Data recorded by PSOs on board source vessels and monitoring vessels during oil and gas activities indicate that seals tend to avoid on-coming vessels (NMFS 2013c). Available information indicates that vessel strikes of seals in the region are low and there is no indication that strikes will become a significant or frequent source of injury or mortality (BOEM 2011).

Effects of Vessel Strike of Steller sea lion

Steller sea lions are broadly distributed throughout the GOARA and BSAIRA and are at risk of vessel strike in those research areas. As discussed in Section 5 (*Environmental Baseline*), four ship strikes of Steller sea lions have been recorded since 2000. Three of those were in Southeast Alaska. Even though no AFSC research activities included in this opinion occur in Southeast Alaska, there are IPHC survey stations within the archipelago. Because IPHC survey vessels operate at an even slower speed, NMFS anticipates that exposure of Steller sea lions to vessel strike is further reduced.

6.2.2.6.4 Summary of potential exposure to vessel strike

Based on the best available information, NMFS expects that the mitigation measures included in AFSC and IPHC research activities as described in Section 2.1.5 will reduce the likelihood of vessel strike to a point that it is discountable for all listed species for the following reasons:

- The research vessels use a slow operational speed, which is typically two to four knots or less during sampling and average about 10 to 12 knots depending on the vessel while in transit. This is generally below the speed at which studies have noted reported increases of marine mammal injury or death (Laist et al. 2001).
- Despite years of likely overlap in time and space, no collisions with large whales have been reported from any fisheries research activities conducted or funded by the AFSC or IPHC.
- All research activities require adherence to the mitigation measures included as part of this action, abiding by the humpback whale approach regulations, and the marine mammal codes of conduct for vessels during transit, and slowing to 10 knots inside designated habitat whenever a marine mammal is spotted. As discussed above, NMFS expects that these mitigation measures will reduce the likelihood of interactions.

NMFS determined vessel strike of listed marine mammals is extremely unlikely to occur and therefore effects from this stressor are considered discountable. No take by vessel strike is authorized in this opinion. No effects to designated critical habitat are expected.

6.2.3 Exposure to Behavioral Harassment

6.2.3.1 Exposure to Acoustic Noise from Surveys

AFSC conducts research surveys that use acoustic gear throughout the GOARA, BSAIRA, and to a lesser extent in the CSBSRA. Because of their juxtaposition in space and time with listed species' general distributions, NMFS anticipates that ESA-listed species could be exposed to acoustic noise.

6.2.3.1.1 Which Listed Species and Critical Habitats may be exposed?

Noise from active acoustic devices used on vessels conducting fisheries research could potentially affect ESA-listed species of fish. However, the source of potentially disturbing sounds would be localized and transient, and the behavioral response of fish would likely be limited to temporary avoidance behavior. Therefore, NMFS concludes that the effects of acoustic noise on listed fish species are insignificant.

In the following analysis, ESA-listed marine mammal species are divided into functional hearing groups to describe the potential overlap of their hearing abilities with the sound emanating from the research gear (

Table 66). Additionally, we analyze the effects of exposure to survey noise on designated critical habitat.

The active acoustic sources have been divided into two categories according to their output frequencies and other characteristics that may affect how marine mammals perceive the sound. These two categories are described below.

Additionally, passive listening sensors, which are sometimes described as elements of fisheries acoustic systems that exist on many oceanographic research vessels, have no potential impact on marine life because they are remotely and passively detecting sound rather than producing it.

Category 1 active acoustic sources

Certain active fisheries acoustic sources (e.g., short range echosounders, acoustic Doppler current profilers) are distinguished by having very high output frequencies (>180 kHz) and generally short duration signals and highly directional beam patterns. Based on the frequency band of transmissions relative to the functional hearing capabilities of marine species, they are not expected to have any negative effect on marine life. They are thus not considered explicitly in this analysis.

These sources are determined to have essentially no probability of being detected by or resulting in any potential adverse impacts on marine species. This conclusion is based on the relative output frequencies (> 180 kHz) and the fact that this is above the known hearing capabilities of any marine species (as described above). Sounds that are above the functional hearing range of marine animals may be audible if sufficiently loud. However, the relative output levels of these sources and the levels that would likely be required for animals to detect them would be on the order of a few meters. The probability for injury or disturbance from these sources is essentially zero. In fact, NMFS usually does not regulate or require take assessments for acoustic sources with source frequencies at or above 180 kHz because they are above the functional hearing range of any known marine animal (including high frequency odontocete cetaceans, such as harbor porpoises (Deng et al. 2014; Hastie et al. 2014)).

Category 2 active acoustic impulsive noise sources

These acoustic sources, which are present on most AFSC fishery research vessels, include a variety of single, dual, and multi-beam echosounders (many with a variety of modes), sources used to determine the orientation of trawl nets, and several current profilers with slightly lower output frequencies than category 1 sources. Category 2 active acoustic sources have moderate to very high output frequencies (10 to 180 kHz), generally short ping durations, and are typically focused (highly directional) to serve their intended purpose of mapping specific objects, depths, or environmental features. A number of these sources, particularly those with relatively lower sound frequencies coupled with higher output levels can be operated in different output modes (e.g., energy can be distributed among multiple output beams) that may lessen the likelihood of perception by and potential impact on marine life.

Category 2 active acoustic sources are likely to be audible to some marine mammal species. Among the marine mammals, most of these sources are unlikely to be audible to whales and most pinnipeds, whereas they may be detected by odontocete cetaceans (and particularly high frequency specialists such as harbor porpoise).

The AFSC deploys Category 2 acoustic equipment that may be heard by marine mammals and may produce sounds loud enough to cause potential Level B harassment in the GOARA, BSAIRA, and CSBSRA regions of Alaska on the surveys in Table 65.

Table 65. AFSC surveys that use Category 2 acoustic equipment, by region.

Survey Region	Survey Title	Acoustic Gear Used	Overlap with hearing range of Functional Hearing Groups
BSAIRA	Aleutian Islands Shelf and Slope Bottom Trawl Groundfish Survey (Biennial)	ES60 and Net Sounders	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Arctic Ecosystem Integrated Survey	ES60	Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Bering Sea Shelf Bottom Trawl Survey	ES60 and Net Sounders	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Eastern Bering Sea Upper Continental Slope Trawl Survey Summer (Biennial)	ES60 and Net Sounders	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds

Survey Region	Survey Title	Acoustic Gear Used	Overlap with hearing range of Functional Hearing Groups
	Pollock Summer Acoustic Trawl Survey - Bering Sea	EK60 Net and Door Sensors	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Pollock Winter Acoustic Trawl Survey - Bogoslof Island (Biennial)	EK60 Net and Door Sensors	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Bering Aleutian Salmon International Survey (BASIS)	Surface Sonar	(At surface - No overlap)
	Acoustic Research and Mapping to Characterize EFH (FISHPAC)	Reson 7111 Single-beam echosounder (38kHz) Multi-beam echosounders (50,100 kHz) Side-scan sonar (180,455 kHz)	Middle frequency Cetaceans Phocid pinnipeds
	Northern Bering Sea Bottom Trawl Survey	Net Sounders and ES60	Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
GOARA	Pollock Summer Acoustic Trawl Survey - Gulf of Alaska (Biennial)	EK60/ME70 Net and Door sensors	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Pollock Winter Acoustic Trawl Survey - Shelikof Strait	EK60/ME70 Net and Door Sensors	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Pollock Winter Acoustic Trawl Survey – Shumagin/Sanak Islands	EK60/ME70 Net and Door sensors	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Gulf of Alaska Shelf and Slope Bottom Trawl Groundfish Survey (Biennial)	Net sounders and ES60	Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Response of Fish to Drop Camera Systems	ES60	Low frequency cetaceans Middle frequency Cetaceans

Survey Region	Survey Title	Acoustic Gear Used	Overlap with hearing range of Functional Hearing Groups
			Phocid pinnipeds Otariid pinnipeds
	Acoustic Research and Mapping to Characterize EFH (FISHPAC)	Reson 7111 Single-beam echosounder (38kHz) Multi-beam echosounders (50,100 kHz) Side-scan sonar (180,455 kHz)	Middle frequency Cetaceans Phocid pinnipeds
CSBSRA	Arctic Ecosystem Integrated Survey	ES60	Low frequency cetaceans Middle frequency Cetaceans Phocid pinnipeds Otariid pinnipeds
	Acoustic Research and Mapping to Characterize EFH (FISHPAC)	Reson 7111 Single-beam echosounder (38kHz) Multi-beam echosounders (50,100 kHz) Side-scan sonar (180,455 kHz)	Middle frequency Cetaceans Phocid pinnipeds

Southall et al. (2007) provided a comprehensive review of marine mammal acoustics including designating functional hearing groups. Assignment was based on behavioral psychophysics (the relationship between stimuli and responses to stimuli), evoked potential audiometry, auditory morphology, and, for pinnipeds, whether they were hearing through air or water. Because no direct measurements of hearing exist for baleen whales, hearing sensitivity was estimated from behavioral responses (or lack thereof) to sounds, commonly used vocalization frequencies, body size, ambient noise levels at common vocalization frequencies, and cochlear measurements. NOAA modified the functional hearing groups of Southall et al. (2007) to extend the upper range of low-frequency cetaceans and to divide the pinniped hearing group into Phocid and Otariid hearing groups (NMFS 2016g). Detailed descriptions of marine mammal auditory weighting functions and functional hearing groups are available in NMFS (2016g). Table 66 presents the functional hearing groups and representative species or taxonomic groups for each that occur in the AFSC research areas. ESA_listed species found in the AFSC project areas include low frequency cetaceans (baleen whales), mid frequency cetaceans (odontocetes), otariids, and phocid pinnipeds.

Table 66. Summary of the five functional hearing groups of marine mammals (NMFS 2016g).

Functional Hearing Group	Estimated Auditory Bandwidth	Species or Taxonomic Groups	Marine Mammals Included in this Biological Opinion
Low frequency cetaceans (Mysticetes–Baleen whales)	7 Hz to 35 kHz (best hearing is generally below 1000 Hz, higher frequencies result from humpback whales)	All baleen whales	Humpback Whale, Mexico DPS Humpback Whale, WNP DPS Fin Whale Bowhead Whale Blue Whale Sei Whale
Middle frequency Cetaceans (Odontocetes)	150 Hz to 160 kHz (best hearing is from approximately 10-120 kHz)	Includes species in the following genera: *Lagenorhynchus,Orcinus, Physeter, Delphinapterus, Monodon, Ziphius, Berardius, Mesoplodon*	Sperm Whales Beluga Whale, Cook Inlet DPS
High frequency cetaceans (Odontocetes)	275 Hz to 160 kHz (best hearing is from approximately 10-150kHz)	Includes species in the following genera: *Phocoena, Phocoenoides*	None
Phocid pinnipeds (true seals)	50 Hz to 86 kHz (best hearing is from approximately 1-30 kHz)	true seals	Ringed Seal, Arctic subspecies Bearded Seal, Beringia DPS
Otariid pinnipeds (sea lions and fur seals)	60 Hz to 39 kHz (best hearing is from approximately 1-16 kHz)	fur seals and sea lions	SSL, western DPS

6.2.3.1.2 Approach to Estimating Exposures to Impulsive Acoustic Noise from Surveys

This analysis uses the following steps to arrive at estimates of exposure of listed species to impulsive sounds from AFSC research survey gear. First, a qualitative description of the functional hearing ranges of listed species was compared to the acoustic outputs of the survey gear revealing which sounds may be audible by the listed species. Those sounds outside of the hearing range are not analyzed further. Next, we analyzed exposure of listed species to acoustic noise within their functional hearing range by evaluating their overlap in time and space using several assumptions, which are detailed below.

1. Qualitative description of overlap between hearing ranges and acoustic outputs

Figure 32 shows the overlap between marine mammal functional hearing ranges and the estimated frequency of sounds emitted by the two categories of acoustic devices used in AFSC research. The black bars indicate the most sensitive hearing ranges of the marine mammals in each group, while the gray bars represent extent of hearing range (Southall et al. 2007). Category 1 and 2 research survey devices are represented by the yellow bars and are described in more detail below. Brackets of sound frequencies at the bottom of the chart are used to illustrate the frequency ranges of several industrial and military sound sources for comparison to the acoustic signatures of the gear used in research surveys.

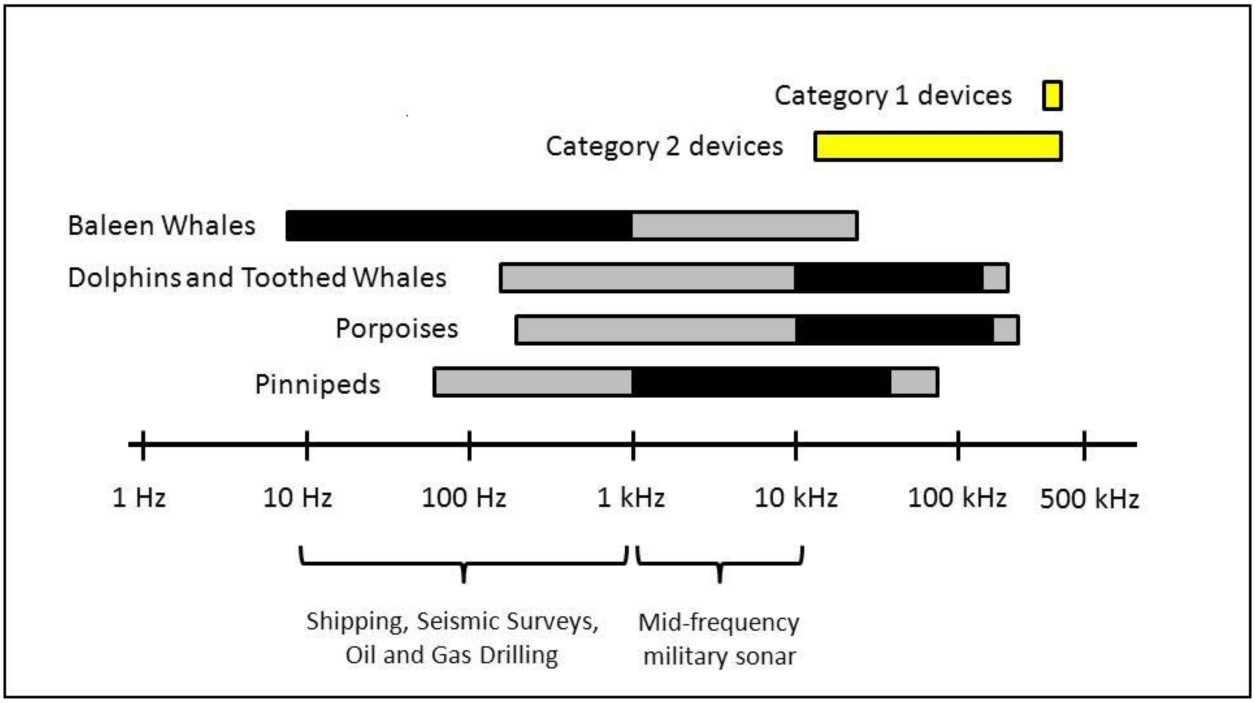

Figure 32. Typical hearing ranges of marine mammals shown relative to various sources of underwater sound.

Category 2 devices used in research activities are described in Table 67. Output frequencies from the equipment used in three acoustic systems is compared to the ranges audible by marine mammal functional hearing groups. This overlap is then used to estimate marine mammal exposure to acoustic noise from specific research activities.

Table 67. Overlap between functional hearing groups of marine mammals and Category 2 acoustic sources used on research surveys

Acoustic system	Operating frequencies (kHz) the full range of frequencies used is shown in parentheses	Functional Hearing Groups for species analyzed in this opinion
ES60	38 kHz (120 kHz)	Middle frequency cetaceans Phocid pinnipeds Otariid pinnipeds
EK60/ME70	18 kHz (38, 70, 120, 200 kHz/70 kHz)	Low frequency cetaceans Middle frequency cetaceans Phocid pinnipeds Otariid pinnipeds
Reson 7111	100 kHz (50, 38 kHz)	Middle frequency cetaceans Phocid pinnipeds

2. Quantitative analysis of exposure of listed species to category 2 acoustic sources

NMFS does not anticipate exposure of any ESA-listed species to Level A acoustic harassment. Level A harassment from acoustic noise is not authorized as part of this action.

Level B harassment may occur when a marine mammal interacts with an acoustic signal and exhibits a behavioral response. Quantifying the spatial and temporal dimensions of the sound exposure footprint of the active acoustic devices in operation on moving vessels and their relationship to the average density of marine mammals enables a quantitative estimate of the number of individuals for which sound levels exceed NMFS Level B Harassment threshold for each area. In order to estimate the footprint of category 2 acoustic sources, the presence of listed species, and their overlap, our analysis includes the following steps:

a) The cross-sectional area of water ensonified to >160 dB rms received level was calculated using a simple model of sound propagation loss;

b) The line distance was calculated for each survey using acoustic gear by accumulating or estimating the distance traveled during targeted survey operations;

c) The effective volume of water ensonified >160 dB rms for the entirety of each survey in each region was calculated for each of the three predominant sound sources;

d) Two-dimensional marine mammal density estimates (animals/km^2) were obtained from various sources for each ecosystem area;

e) The vertical stratification of marine mammals based on known or reasonably assumed diving behavior was integrated into the density estimates to calculate volumetric densities; and

f) The estimated exposures (Table 75) are the product of the volume of water ensonified at 160 dB rms or higher and the volumetric density of animals for each species.

Methods for estimating each of these calculations are described in greater detail in the following sections, along with the simplifying assumptions made, and followed by the exposure estimates for each of the three research areas where the AFSC conducts fisheries research.

Assumptions included in estimation of exposure

This analysis of exposure to acoustic noise includes several modifications specific to the directional nature of high-frequency fisheries acoustic sources, the vertical stratification of marine species, and what is currently known about the hearing capabilities of marine mammals. Given the simplistic step-function approach, the lack of available species-specific hearing parameters, large uncertainty in some areas, and a number of underlying assumptions based on how these sources may be used variably in the field, this approach should be considered to result in a precautionary estimate of potential impact (e.g., higher estimated “takes” than are in fact likely). Factors believed to result in the estimated Level B harassment by acoustic sources being conservative (i.e., higher than what may actually occur in situ) include assumptions about marine mammal hearing abilities, noise production, and depths of interactions as discussed below.

Assumptions about depth

Because depths range dramatically along the margin of the continental slope that define the outer edge of the survey areas, the depth range for determining volumes was set at 500 m for deep diving species because surveyed depths are rarely below 500 m. Therefore, the number of Level B harassment events is ultimately estimated as the product of the volume of water ensonified to 500 m and at sound intensities greater than 160 dB rms, with the volumetric density of animals determined from simple assumptions about their vertical stratification in the water column. Specifically, reasonable assumptions based on what is known about diving behavior and onshore and offshore distributions among different marine mammal species were made to segregate those that predominately remain in the upper 200 meters versus those that regularly dive deeper during foraging and transit and for those animals that reside in inshore-shelf waters and shelf and offshore waters. It should also be recognized that the estimates of take by acoustic sources take into account that more than one animal could be ensonified several times.

Assumptions about marine mammal hearing

While the hearing ranges of the functional hearing groups ((NMFS 2016g)) are accounted for in a straightforward manner in these calculations (i.e., sources are considered unlikely to lead to any Level B harassment if they are above or below functional hearing cut-offs), the known differences in hearing sensitivities between different marine mammal species, and within a functional hearing range (e.g., as reflected in auditory weighting functions), are not considered in estimates of Level B harassment by acoustic sources. All species are assumed to be equally sensitive to acoustic systems operating within their functional hearing range.

Other known aspects of hearing as they relate to transient sounds (specifically auditory integration times) are also not taken into account in this estimation. Specifically, sounds associated with these fisheries acoustic sources are typically repetitive and quite brief in duration. All Sound Pressure Levels (SPLs) are calculated by assuming a continuous transmission, without taking into account the duty cycle, i.e., the ratio of pulse duration to ping interval. While some animals may potentially hear these signals well (e.g., odontocete cetaceans), for other animals the perceived sound loudness may be considerably reduced based on their brief nature and the fact that auditory integration times in many species likely exceed the duration of individual signals. More research is needed, however, in order to be able to quantify any potential reduction in perceived received level due to the brief nature of the sounds and to determine to which species this applies.

Assumptions about noise production

Several other precautionary assumptions are made, including the use of the lowest frequencies and highest output power levels utilized (with greatest potential propagation leading to higher received levels) in cases where source operational parameters may be varied.

Many of these sources can be operated in different modes and with different output parameters. In modeling their potential impact areas for these vessels when used and also when they are operated from non-NOAA vessels used for AFSC survey operations, those features among those given below that would lead to the most precautionary estimate of maximum received level ranges (i.e., largest ensonified area) were used (e.g., lowest operating frequency). These operating characteristics of each of the predominant sound sources were used in the calculation of effective line km and area of exposure specific to each source in each survey.

The AFSC calculated a metric called the "total effective line kilometer" for each vessel (described further in Sections 6.2.2 and 6.2.3 of the LOA application). This metric is an estimate of the relative percentage of a surveyed transect that was associated with a particular sound source. In determining the effective line km for each of these predominant sources the operational patterns of use relative to one another were further applied to determine which source was the predominant one operating at any point in time for each survey. When multiple sound sources were used simultaneously, the one with the largest potential impact zone in each relevant depth strata was used in calculating takes. For example, when species (e.g., sperm whales) regularly dive deeper than 200 meters, the largest potential impact zone was calculated for both depth strata and in some cases resulted in a different source being predominant in either depth strata. This enabled a more comprehensive way of accounting for maximum exposures for animals diving in a complex sound field resulting from simultaneous sources with different spatial profiles. This overall process effectively resulted in three sound sources (ES60, EK60/ME70, and Reson 7111) comprising the total effective line km and their relative proportions depending on the nature of each survey (Table 68).

2a. Calculating area ensonified

Among those acoustic systems operating within the audible band of marine mammal hearing (Category 2), three predominant sources were identified as having the largest potential impact zones during operations, based on their relatively lower output frequency, higher output power, and their operational pattern of use (Table 68).

Table 68. Output characteristics for predominant AFSC acoustic sources

Acoustic system	Operating frequencies (kHz)	Source level (dB re 1 µPa at 1 m)	Nominal beam width (deg)	Effective exposure area: Sea surface to 200 m depth (km^2)	Effective exposure area: sea surface to 500 m depth (km^2)	Effective exposure area: Sea surface to depth at which sound is attenuated to 160 dB SPL (km^2)
ES60	38 kHz (120 kHz)	226.6	7	0.0112	0.0112	0.0712
EK60/ME70	18 kHz (38, 70, 120, 200 kHz/70 kHz)	226.7	11	0.0173	0.0561	0.2173
Reson 7111	100 kHz (50, 38 kHz)	230	150	0.1419	0.9144	1.204
Note: Calculations of effective exposure areas are made with the lowest frequency from sources with multiple frequencies; the full range of frequencies used is shown in parentheses. Abbreviations: dB re 1 µPa at 1 m = decibels referenced at one micro Pascal at one meter; km^2 = square kilometer						

The cross-sectional area of water ensonified to 160+ dB rms received level was calculated using a simple model of sound propagation loss, which accounts for the loss of sound energy over increasing range. We used a spherical spreading model (where propagation loss = 20 x log (range) - such that there would be 60 dB of attenuation over 1000 m). This is a reasonable assumption even in relatively shallow waters since, taking into account the beam angle, the reflected energy from the seafloor will be much weaker than the direct source and the volume influenced by the reflected acoustic energy would be much smaller over the relatively short ranges involved. The spherical spreading model accounted for the frequency dependent absorption coefficient and the highly directional beam pattern of most of these sound sources. For absorption coefficients, the most commonly used formulas given by Francois and Garrison (1982) were used. The lowest frequency was used for systems that are operated over a range of frequencies. The vertical extent of this area is calculated for two depth strata (surface to 200 m, and for deep water operations, surface to range at which the on-axis received level reaches 160 dB rms up to 500 m depth). This was applied differentially based on the typical vertical stratification of marine mammals. A simple visualization of a two-dimensional slice of modeled sound propagation is shown in Figure 33 to illustrate the predicted area ensonified to the 160 dB level by an EK-60 operated at 18 kHz.

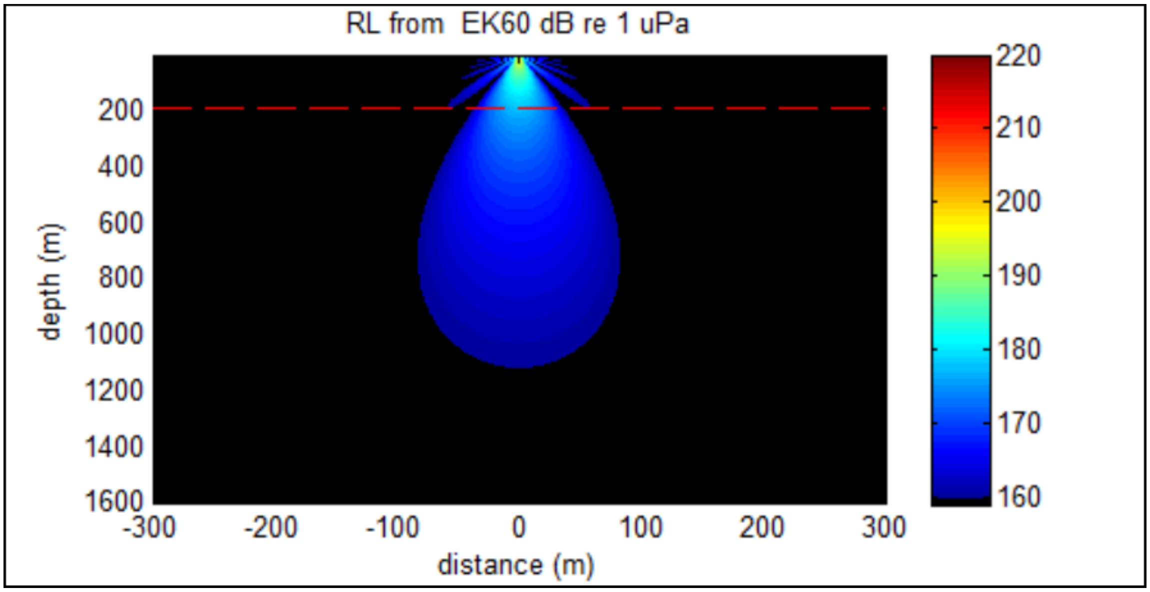

Figure 33. Visualization of a two-dimensional slice of modeled sound propagation to illustrate the predicted area ensonified to the 160 dB level by an EK-60 operated at 18 kHz. The dashed red line marks the transition between the two depth strata (0-200 m and >200 m).

2b. Calculating Effective Line Kilometer for Each Vessel

Estimated volumes of water ensonified to the 160 dB rms received level and water ensonified to 500 m was determined based on the operating parameters for each sound source type as described below. In all cases where multiple sources are operated simultaneously, the one with the largest estimated acoustic footprint (and thus leading to higher estimated Level B harassment) was used as the effective source. Two depth zones were defined for each of the three research areas: 0-200 m and > 200 m, generally relating to operations on the shallower upper Continental Shelf and those in deeper waters. Effective line distance and volume ensonified was calculated for each depth strata (0-200 m and > 200 m), where appropriate. In some cases, this resulted in different sources being predominant in each depth strata for all line km when multiple sources were in operation; this was accounted for in estimating overall exposures for species that utilize both depth strata (deep divers). The line distance was calculated for each survey using acoustic gear by accumulating or estimating the distance traveled during targeted survey operations and did not include the distances running between stations or to port. For each AFSC research area, the total number of line km that would be surveyed was determined, as was the relative percentage of surveyed linear km associated with each source.

2c. Calculating Volume of Water Ensonified to 160 dB RMS Received Level

Following the determination of effective sound exposure area for transmissions considered in two dimensions, the next step was to determine the effective volume of water ensonified >160 dB rms for the entirety of each survey in each region. For each of the three predominant sound sources, the volume of water ensonified is estimated as the athwartship cross-sectional area (in

km^2) of sound above 160 dB rms (as shown in the figure above) multiplied by the total distance traveled by the ship. When different sources are operating simultaneously, they may be predominant in different depth strata (e.g., if ME70 and EK60 are operating simultaneously, the ME70 could be predominant in shallow water but the EK60 could be predominant in deeper water). The resulting calculated cross sectional area took this into account. Specifically, for shallow-diving species this cross-sectional area was determined for whichever was predominant in the shallow strata, whereas for deeper diving species in deeper water this area was calculated from the combined effects of the predominant source in the shallow strata and the sometimes different source predominating in the deeper strata. This creates an effective total volume that characterizes the area ensonified when each predominant source is operated and accounts for the fact that deeper diving species may encounter a complex sound field in different portions of the water column. These same inputs were used to determine the volume of water ensonified to a depth of 500 m. Results are shown in Table 69.

Table 69. Annual linear survey distance and volume ensonified to 160 dB for each survey using NOAA and charter vessels and the dominant sources within two depth strata for each of the three AFSC research areas. Only the sound sources that were the dominant sources of sound during AFSC research are shown.

Vessel **Survey**	**Total Distance (km/vessel) over five years [a]**	**Source**	**% of Distance Source Dominant (0-200m)**	**% of Distance Source Dominant (>200m)**	**Line km source <200m**	**Line km source >200m**	**Volume Ensonified 0-200 m Depth (km^3)**	**Volume Ensonified 0-500 m Depth (km^3)**	**Volume Ensonified Full Depth (surface to on-axis range at which SL is attenuated to 160 dB) (km^3)**
GULF OF ALASKA RESEARCH AREA									
R/V *Oscar Dyson* Pollock Summer Acoustic Trawl (GOA biennial)	17558	EK60/ ME70	74%	26%	12993	4565	224.778	256.101	991.992
R/V *Oscar Dyson* Pollock Winter Acoustic Trawl Survey - Shelikof Strait	9540	EK60/ ME70	31%	69%	2957	6583	51.163	369.284	1430.399
R/V *Oscar Dyson* Pollock Winter Acoustic Trawl Survey – Shumagin/ Sanak Islands	4520	EK60/ ME70	99%	1%	4475	45	77.414	2.536	9.822
Charter Vessels (3) Gulf of Alaska Shelf and Slope Bottom Trawl Groundfish Survey (Biennial)	9189	ES60	76%	24%	6983.64	2205.36	78.217	79.393	157.022
BERING SEA/ALEUTIAN ISLANDS RESEARCH AREA									
Charter Vessels (2) Aleutian Islands Shelf and Slope Bottom Trawl Groundfish Survey (Biennial)	3190	ES60	61%	39%	1946	1244	21.794	44.788	88.580
Charter Vessel Arctic Ecosystem Integrated Survey	2599	ES60	100%	0%	2599	0	29.109	0	0
Charter Vessels (2) Bering Sea Shelf Bottom Trawl Survey	11200	ES60	100%	0%	11200	0	125.440	0	0

Vessel **Survey**	**Total Distance (km/vessel) over five years [a]**	**Source**	**% of Distance Source Dominant (0-200m)**	**% of Distance Source Dominant (>200m)**	**Line km source <200m**	**Line km source >200m**	**Volume Ensonified 0-200 m Depth (km^3)**	**Volume Ensonified 0-500 m Depth (km^3)**	**Volume Ensonified Full Depth (surface to on-axis range at which SL is attenuated to 160 dB) (km^3)**
Charter Vessel Eastern Bering Sea Upper Continental Slope Trawl Survey Summer (Biennial)	1125	ES60	0%	100%	0	1125	0.000	40.500	80.100
R/V *Oscar Dyson* Pollock Summer Acoustic Trawl Survey - Bering Sea	25460	EK60/ ME70	91%	9%	23169	2291	400.817	128.548	497.921
R/V *Oscar Dyson* Pollock Winter Acoustic Trawl Survey - Bogoslof Island (Biennial)	2788	EK60/ ME70	15%	85%	418	2370	7.235	132.946	514.958
Charter Vessel Bering Aleutian Salmon International Survey (BASIS)	12288	ES60	95%	5%	11674	614	130.744	34.468	43.745
R/V *Fairweather* Acoustic Research and Mapping to Characterize EFH (FISHPAC)	145	Reson 7111	100%	0%	145	0	20.576	0	0
Charter Vessel Response of Fish to Drop Camera Systems	259	ES60	100%	0%	259	0	2.901	0	0
Charter Vessel Northern Bering Sea Bottom Trawl Survey	1440	ES60	100%	0%	1440	0	16.128	0	0
CHUKCHI SEA/BEAUFORT SEA RESEARCH AREA									
Charter Vessel Arctic Ecosystem Integrated Survey	5915	ES60	100%	0%	5915	0	66.248	0	0

a. Estimated Annual Active Lineal Distance (km) - This considers ONLY effective line effort of active acoustic operations directed at mobile survey efforts (not transit or other non-directed times) for each research area.

2d. Two-dimensional Species-specific Marine Mammal Densities-Approach and Assumptions

One of the primary limitations to traditional estimates of acoustic exposure is the assumption that animals are uniformly distributed in time and space across very large geographical areas, such as those being considered here. There is ample evidence that this is in fact not the case and marine species are highly heterogeneous in terms of their spatial distribution, largely as a result of species-typical utilization of heterogeneous ecosystem features. Some more sophisticated modeling efforts have attempted to include species typical behavioral patterns and diving parameters in movement models that more adequately assess the spatial and temporal aspects of distribution and thus exposure to sound. While simulated movement models were not used to mimic individual diving or aggregation parameters in the determination of animal density in this estimation, the vertical stratification of marine mammals based on known or reasonably assumed diving behavior was integrated into the density estimates used. That process is described in step 2e.

Two-dimensional marine mammal density estimates (animals/km^2) are based on the best available information obtained for each research area, including marine mammal Stock Assessment Reports and other sources (Table 70). There are a number of caveats associated with these estimates that could have varying effects on their accuracy:

- They are often calculated using visual sighting data collected during one season rather than throughout the year. The time of year when data were collected and from which densities were estimated may not always overlap with the timing of AFSC fisheries research surveys.
- Marine mammal survey areas do not necessarily coincide spatially with the entire AFSC and IPHC fisheries research area boundaries. Estimated densities from the survey areas are assumed to apply to the entire research area.
- The densities used for purposes of estimating acoustic harassment takes do not take into account the patchy distributions of marine mammals in an ecosystem, at least on the moderate to fine scales over which they are known to occur. Instead, animals are considered evenly distributed throughout the assessed area and seasonal movement patterns are not taken into account.

Table 70. Sources of marine mammal density information. NMFS used the best available information to analyze effects of the action. Note that estimates for abundance and density were available for some species by stock, and for others, by distinct population segment. Take estimates, presented later in this document, refer to the DPS or listed entity of each species, as appropriate.

Species/Stock	Source of estimate (e.g., reference, short description of process used to estimate density)
GOARA	
Beluga whale - Cook Inlet DPS	Based on 2014 abundance estimate and region in upper CI where whales were found (340 whales within 1740 sq. km). Note: found at river mouths this density could be as high as 1.1/sq. km
Blue whale – Eastern North Pacific Stock	(Rone et al. 2017)
Fin whale - Northeast Pacific Stock	NMML staff, publication in review.
Humpback whale - Central North Pacific Stock	(Zerbini et al. 2006) Took highest density of any block from Zerbini et al. 2006, which was 0.066 in block 5. Prorated stocks according to Wade et al. (2016), with 99% CNP and 1% WNP in BSAI, resulting in 0.0653 for CNP and 0.0007 for WNP.
Humpback whale - Western North Pacific Stock	(Zerbini et al. 2006) Took highest density of any block from Zerbini et al. 2006, which was 0.066 in block 5. Prorated stocks according to Wade et al. (2016), with 99% CNP and 1% WNP in BSAI, resulting in 0.0653 for CNP and 0.0007 for WNP.
North Pacific right whale - Eastern North Pacific Stock	The GOALSII survey had 4 acoustic detections near or in the Critical Habitat area (Rone et al. 2014). The number of photo identifications in the Gulf of Alaska (including BC) in recent years is also 4. It is plausible that all Gulf of Alaska right whales move up onto the shelf area off Kodiak to take advantage of concentrations of diapausing zooplankton that occur in mid to late summer (Wade et al. 2011b). Therefore, a cautious approach (calculating a maximum density) would be a total number from the GOA divided by the area of the Critical Habitat. The number of located or identified whales (4) was arbitrarily multiplied by 4 to account for undetected whales (note that the correction in the Bering Sea was much less (Wade et al. 2011a), so this is hopefully conservative). Therefore, the density is calculated as 16 divided by 3042.2 sq. km.
Sei whale – Eastern North Pacific Stock	2 ind/ 321,750 km2 Area of POWER2010 transects within EEZ with 2 sightings; Figure 2b (top) in 2010 Japan Joint Cetacean Sighting Survey Cruise in the North Pacific (IWC)
Sperm whale - North Pacific Stock	NMML staff, publication in review.
Steller sea lion - Western DPS GOA wide	Pup production * 4.5 in E ALEU + W GULF + C GULF + E GULF in 2014 100% W of 144° W. longitude N=42,129; East of 144° W. longitude N=917 (Fritz et al. 2013)
BSAIRA	
Bearded seal - Beringia DPS	Conn et al. (2014) has the most recent abundance estimates for the Bering Sea.
Bowhead whale - Western Arctic Stock	See Chukchi-Beaufort
Fin whale - Northeast Pacific Stock	(Friday et al. 2013)

Species/Stock	Source of estimate (e.g., reference, short description of process used to estimate density)
Humpback whale - Central North Pacific Stock	Took highest density of any block from (Zerbini et al. 2006), which was 0.02 in block 12. Prorated stocks according to (Wade et al. 2016), with 92% CNP and 8% WNP in AIBS, resulting in 0.0184 for CNP and 0.0016 for WNP.
Humpback whale - Western North Pacific Stock	Took highest density of any block from (Zerbini et al. 2006), which was 0.02 in block 12. Prorated stocks according to (Wade et al. 2016), with 92% CNP and 8% WNP in AIBS, resulting in 0.0184 for CNP and 0.0016 for WNP.
North Pacific right whale - Eastern North Pacific Stock	Took abundance estimate from Wade et al. (2011a) of 31 whales, and divided by area of critical habitat, calculated as 92,698 sq. km. This assumes all whales could be in the critical habitat area at one time.
Ringed seal - Arctic Subspecies/Alaska Stock	Conn et al. (2014) has the most recent abundance estimates for the Bering Sea. n= 171,418 for ice covered area of the US sector of the Bering Sea (apply an approximate c.f. of 0.64 to get 267,841)
Sei whale – Eastern North Pacific Stock	From (Friday et al. 2013): used minke whale detection function and sei whale encounter rate
Sperm whale - North Pacific Stock	Density computed for DART blocks 13-16 (the ones with sperm whale sigthings in the Aleutian). n/L and mean s is from DART, ESW is from Branch and Butterworth 2001 for sperm whales
Steller sea lion - Western DPS	(Pup production * 4.5 in W Aleu, C Aleu, E Aleu and Bering 2014:N = 25,164) + (5% Pup production * 4.5 in W Gulf, C Gulf, E Gulf 2014 N=1467); total N = 26631; latter accounts for wDPS males from Gulf in BSAI, MML staff.
CSBSRA	
Bearded seal - Beringia DPS	Bengtson et al. (2005) has the most recent density estimates for the Chukchi Sea. The survey was conducted in May. There are no surveys for the Beaufort, so used the average Chukchi density (km2) estimates shown for the entire LME.
Bowhead whale - Western Arctic Stock	ASAMM 2008-2014 survey data. See MML's R code ArcticLMEdensity.r for summary of methods and code. Density estimate was highest pooled monthly estimate for either August or September for the 35-50 m depth zone in the Chukchi Sea.
Fin whale – Northeast Pacific stock	Sample sizes too low to calculate density estimates, so the density estimate represents expert opinion. Max depth at sighting in the ASAMM 1979-2014 historical database is 52 m.
Humpback whale - Central North Pacific Stock	ASAMM 2008-2014 survey data. See MML's R code ArcticLMEdensity.r for summary of methods and code. Stock unknown. Max depth of water at sighting in the ASAMM 1979-2014 database is 61 m.
Humpback whale - Western North Pacific Stock	ASAMM 2008-2014 survey data. See MML's R code ArcticLMEdensity.r for summary of methods and code. Stock unknown. Max depth of water at sighting in the ASAMM 1979-2014 database is 61 m.
Ringed seal - Arctic Subspecies/Alaska Stock	Bengtson et al. 2005, has the most recent density estimates for the Chukchi Sea. The survey was conducted in May. There are no surveys for the Beaufort, so used the average Chukchi density (km2) estimates shown for the entire LME.

2e. Three-dimensional density

To account for at least some coarse differences in marine mammal diving behavior and the effect this has on their likely exposure to these highly directional sound sources, a volumetric density of marine mammals of each species was determined. Volumetric density of listed species was estimated using marine mammal abundance averaged over the two-dimensional geographic extent of the surveys and the depth range of typical habitat for the population. Habitat ranges were categorized in two generalized depth strata (0-200 m, and 0 to >200 m) based on gross differences between surface-associated and deep-diving marine mammals, in general terms. Animals in the shallow diving strata were reasonably estimated, based on empirical measurements of diving with monitoring tags and reasonable assumptions of behavior based on other indicators the animals spend a large majority of their lives (>75 percent) at depths of 200 m or shallower. Their volumetric density and thus exposure to sound is limited by this depth boundary. Species in the deeper diving strata were estimated to regularly dive deeper than 200 m and spend significant time at these greater depths. Their volumetric density and thus potential exposure to sounds up to the 160 dB rms level is extended from the surface to the depth at which this received level condition occurs and/or the water depth in the region of interest (e.g., the Continental Shelf region was generally considered to be comprised of water no deeper than 500 m, the outer limit of most research surveys).

The volumetric densities are estimates of the three-dimensional distribution of animals in their typical depth strata. For shallow diving species or in regions where water depth is <200m (e.g., CSBSRA) the volumetric density is the area density divided by 0.2 km (i.e., 200 m depth). For deeper diving species, the volumetric density is the area density divided 0.5 km (i.e., 500 m depth). The two-dimensional and resulting three-dimensional (volumetric) densities for each species in each AFSC fisheries research area are shown in Table 71, Table 72, and Table 73.

Volumetric densities and takes were further affected by whether the species occurred in inshore or offshore waters. Most species designated as shallow divers (<200 m depth) were considered to be shelf and inshore species, and their lineal distance was the extent of survey areas to 200 m in depth. However, some shallow diving species also occur in offshore waters so the density to 200 m depth was applied to the volumetric density of all survey tracks. These species include Steller sea lion; humpback and sei whales in the BSAIRA; and bearded and ringed seals in the BSAIRA. Ensonified volumes for deep diving species were summed for the shallow inshore component and the deeper waters.

Table 71. Volumetric densities calculated for each species in the GOARA used in Level B Acoustic Take estimation

Species (common name)	**Typical Dive Depth Strata**		**Area density (#/km^2)**	**Volumetric density (#/km^3)**
	0-200 m	**>200 m**		
GULF OF ALASKA RESEARCH AREA				
Beluga whale - Cook Inlet DPS	X		0.2	1
Blue whale - Eastern North Pacific	X		0.0001	0.0005
Fin whale - Northeast Pacific	X		0.02	0.1
Humpback whale - Central North Pacific	X		0.0653	0.3265
Humpback whale - Western North Pacific DPS	X		0.0007	0.0035
North Pacific right whale - Eastern North Pacific	X		0.0053	0.0265
Sei whale - Eastern North Pacific	X		0.000006	0.00003
Sperm whale - North Pacific		X	0.001	0.002
Steller sea lion - Western DPS GOA wide	X		0.0351	0.1755
Steller sea lion - Western DPS E 144	X		0.0029	0.0145
Steller sea lion - Western DPS W 144	X		0.0478	0.239

Table 72. Volumetric densities calculated for each species in the BSAIRA used in Level B Acoustic Take estimation

Species (common name)	**Typical Dive Depth Strata**		**Area density (#/km^2)**	**Volumetric density (#/km^3)**
	0-200 m	**>200 m**		
BERING SEA – ALEUTIAN ISLANDS RESEARCH AREA				
Bearded seal - Beringia DPS	X		0.3935	1.9675
Bowhead whale - Western Arctic	X		0.017	0.085
Fin whale - Northeast Pacific	X		0.0014	0.007
Humpback whale - Central North Pacific	X		0.0184	0.092
Humpback whale - Western North Pacific	X		0.0016	0.008
North Pacific right whale - Eastern North Pacific	X		0.0003	0.0015
Ringed seal - Arctic Subspecies/Alaska	X		0.3492	1.746
Sei whale - Eastern North Pacific	X		0.00018	0.0009
Sperm whale - North Pacific		X	0.008	0.016

Species (common name)	Typical Dive Depth Strata		Area density (#/km²)	Volumetric density (#/km³)
	0-200 m	>200 m		
Steller sea lion - Western DPS	X		0.0119	0.0595

Table 73. Volumetric densities calculated for each species in the CSBSRA used in Level B Acoustic Take estimation

Species (common name)	Typical Dive Depth Strata		Area density (#/km²)	Volumetric density (#/km³)
	0-200 m	>200 m		
CHUKCHI SEA – BEAUFORT SEA RESEARCH AREA				
Bowhead whale - Western Arctic	X		2.27	11.35
Fin whale - Northeast Pacific	X		0.0001	0.0005
Humpback whale - Central North Pacific	X		0.0001	0.0005
Humpback whale - Western North Pacific	X		0.0001	0.00005
Ringed seal - Arctic Subspecies/Alaska	X		1.765	8.825
Bearded seal - Beringia DPS	X		0.175	0.875

*2f. Using Areas Ensonified and Volumetric Density to Calculate Acoustic Exposur*e

Level B harassment by acoustic sources, according to current NMFS guidelines, has been calculated for each AFSC fisheries research area by using (1) the combined results from output characteristics of each source and identification of the predominant sources in terms of usage and acoustic output, (2) their relative annual usage patterns for each operational area, (3) a source-specific determination made of the area of water associated with received sounds at either the extent of a depth boundary or the 160 dB rms received sound level, and (4) determination of a biologically-relevant volumetric density of marine mammal species in each area.

These exposure estimates for each of the three AFSC fisheries research areas are presented in Table 74, Table 75, and Table 76. They are the product of (1) the volume of water ensonified at 160 dB rms or higher for the predominant sound source for each portion of the total line km for which it is used and (2) the volumetric density of animals for each species in that area.

Special estimation procedures for baleen whales, Cook Inlet Beluga Whales, and North Pacific Right Whales

The acoustic take estimates were modified from this general approach for baleen whales. Note that acoustic Level B takes were set to zero for baleen whales exposed to sonar systems that operated above 25 kHz, i.e. the ES60 system, because the frequency is above the range of the low frequency cetacean functional hear group (Table 66 and Figure 32). Also, no surveys are conducted in waters deeper than 200m in the CSBSRA; therefore no take is requested for deep and offshore waters in the CSBSRA.

The general approach was further modified for Cook Inlet beluga whales. Surveys using EK60/ME70 or the Reson systems do not overlap with Cook Inlet beluga whales. However, 20 out of 825 (2.4%) stations of the bottom trawl survey using the ES60 frequencies typically occur in the southern third of Cook Inlet (Figure 34). Due to the limited range of Cook Inlet beluga whales, the estimated exposure was reduced relative to the overlap of research activities with their distribution. The number of stations in the overlap area was used to calculate a percentage of total GOARA stations. This percentage was then applied to the exposure estimate from the method described above, to reflect the more likely acoustic exposure. We estimate three Cook Inlet beluga whales will be exposed to acoustic noise from the bottom trawl survey, annually. We expect similar levels of interactions to continue into the foreseeable future.

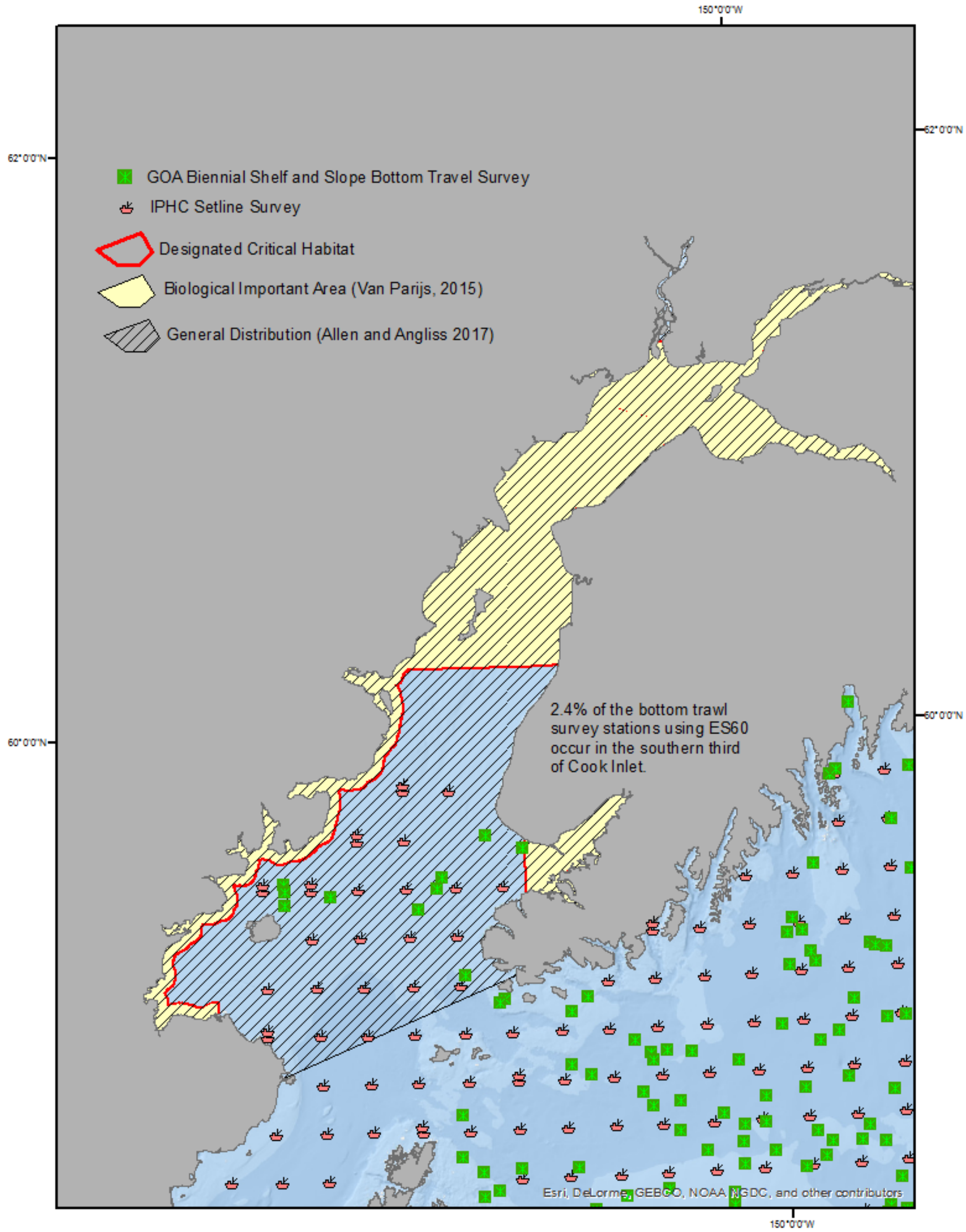

Figure 34. Cook Inlet beluga whale general distribution, biological important area, designated critical habitat, IPHC setline survey stations, and GOA biennial shelf and slope bottom trawl survey stations.

Because of their rarity, the acoustic takes for North Pacific right whales were estimated by a special procedure. Since only the Summer Pollock Acoustic-Trawl Surveys operate sonars at low frequencies that may affect this species, the percentage of acoustic track lines from these surveys within North Pacific right whale critical habitats in the GOARA and BSAIRA relative to the entire track lines in each research area were calculated. For the GOARA, the percentage was 1.66 of the 8,396 km of track line, and for the BSAIRA, the percentage was 18.93 for the 10,235 km of trackline (Figure 26). These percentages were applied to the distance expected to be traveled during the next five years of summer pollock acoustic-trawl surveys in both areas, and then acoustic takes were estimated in a similar manner to other species and surveys. We estimate one North Pacific right whale total (rounded up from 0.1) will be exposed to acoustic noise from the pollock survey in both the GOARA and the BSAIRA annually . We expect similar levels of interactions (two North Pacific right whale exposures annually) to continue into the foreseeable future.

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Table 74. Estimated acoustic exposure (Level B harassment) by sound type for each marine mammal species in the GOARA

Species	Volumetric Density (#/km^3)	Estimated Number of animals over five years exposed to Level B acoustic harassment in the GOARA								
		0-200m				>200m				Total Level B Exposures (rounded up)
		EK60 (18kHz)		ES60 (38kHz)		EK60 (18kHz)		ES60 (38kHz)		
		Volume Ensonified	Exposures	Volume Ensonified	Exposures	Volume Ensonified	Exposures	Volume Ensonified	Exposures	
Beluga whale - Cook Inlet DPS	1	0	0	2.47	2.5	0	0	0	0	**3**
Blue whale - Eastern North Pacific	0.0005	353.4	0.2	78.2	0	627.9	0	79.4	0	**1**
Fin whale - Northeast Pacific	0.1	353.4	35.3	78.2	7.8	627.9	0	79.4	0	**36**
Humpback whale - Central North Pacific Stock	0.3265	353.4	115.4	78.2	0	627.9	0	79.4	0	**116**
Humpback whale - Western North Pacific Stock	0.0035	353.4	1.2	78.2	0	627.9	0	79.4	0	**2**
North Pacific right whale - Eastern North Pacific	0.0265	3.7	0.1	0	0	0	0	0	0	**1**
Sei whale - Eastern North Pacific	0.00003	353.4	0.011	78.2	0	628	0	79.4	0	**1**
Sperm whale - North Pacific	0.002	353.4	0.7	78.2	0.2	627.9	1.3	79.4	0.2	**3**
Steller sea lion - Western DPS GOA wide	0.1755	547	96.0	102.9	18.1	0	0	0	0	**115**
Steller sea lion - Western DPS E 144	0.0145	547	7.9	102.9	1.5	0	0	0	0	**10**
Steller sea lion - Western DPS W 144	0.239	547	130.7	102.9	24.6	0	0	0	0	**156**

Table 75. Estimated acoustic takes (Level B harassment) by sound type for each marine mammal species in the BSAIRA

Species	Volumetric Density (#/km^3)	Estimated Number of animals over five years exposed to Level B acoustic harassment in the BSAIRA										
		0-200m						>200m				Total Level B Exposures (rounded up)
		EK60 (18kHz)		ES60 (38kHz)		Reson 7111 (100 kHz)		EK60 (18kHz)		ES60 (38kHz)		
		Volume Ensonified	Exposures	Volume Ensonified	Exposures	Volume Ensonified	Exposures	Volume Ensonified	Estimated Take	Volume Ensonified	Exposures	
Bearded seal - Beringia DPS	1.9675	488.7	961.5	359.5	707.4	20.6	40.5	0	0	0	0	**1669**
Bowhead whale - Western Arctic	0.085	488.7	41.5	359.5	0	20.6	0	0	0	0	0	**42**
Fin whale - Northeast Pacific	0.007	488.7	3.4	359.5	0	20.6	0	0	0	0	0	**4**
Humpback whale - Central North Pacific Stock	0.092	488.7	45.0	359.5	0	20.6	0	0	0	0	0	**45**
Humpback whale – Western North Pacific Stock	0.008	488.7	3.9	359.5	0	20.6	0	0	0	0	0	**4**
North Pacific right whale - Eastern North Pacific	0.0015	75.87	0.1	346.7	0	20.6	0	261.5	0	119.8	0	**1**
Ringed seal - Arctic Subspecies/Alaska	1.746	488.7	853.3	359.5	627.7	20.6	35.9	0	0	0	0	**1481**
Sei whale - Eastern North Pacific	0.0009	488.7	0.4	359.5	0	20.6	0	0	0	0	0	**1**
Sperm whale - North Pacific	0.016	408.1	6.5	346.7	5.5	20.6	0.3	261.5	4.2	119.8	1.9	**19**
Steller sea lion - Western DPS	0.0595	488.7	29.1	359.5	21.4	20.6	0	0	0	0	0	**51**

Table 76. Estimated acoustic exposures (Level B harassment) by sound type for each marine mammal species in the CSBSRA

Species[1]	Volumetric Density (#/km^3)	Estimated Number of animals over five years exposed to Level B acoustic harassment in the CSBSRA		
		0-200 m[2]		Total Level B Exposures (rounded up)
		ES60 (38kHz)		
		Volume Ensonified	Level B Exposures	
Bearded seal - Beringia DPS	0.875	66.2	57.97	**58**
Ringed seal - Arctic Subspecies/Alaska	8.825	66.2	584.6	**585**

[1] In the CSBSRA, the only sources used are above the hearing threshold of bowhead, fin, and humpback whales, thus no Level B takes are requested.
[2] There are no surveys in waters deeper than 200m in the CSBSRA; therefore no take is requested for deep and offshore waters in the research area.

These exposures are likely overestimates for the following reasons.

- Some surveys that only occur every 2 or 3 years have been counted as annual surveys for 5-year estimates.
- Seasonal migrations of bowhead whales and possibly other species likely further reduce the potential for overlap between surveys and animal presence.

In-air exposure to sound pressure

In-air sound exposure is not analyzed for cetacean species. NMFS uses an in-air pressure level of 100 dB re 20µPa$_{rms}$ to define Level B harassment for non-harbor seal pinnipeds; however, we do not analyze in-air sound pressure levels with potential to affect pinniped hearing in this opinion. No sounds associated with this action are expected to rise to Level B harassment in regards to effects to hearing. We do analyze terrestrial disturbance from visual and auditory stimuli during the operation of the research activities; for example, vessel noise at a particular station, deploying and retrieving gear, and on-deck communication. This exposure is not anticipated to affect hearing, but rather may cause behavioral responses (e.g., flushing, vocalizing, and head alerts), and is analyzed under the 'terrestrial disturbance' stressor in the next section.

6.2.3.1.3 Summary of potential exposure to acoustic noise

Using the methods detailed above, NMFS expects the listed species included in

Table 77 below could be exposed to Level B harassment from acoustic noise during AFSC and IPHC research activities. The potential effects to designated critical habitat are analyzed in the next section.

Table 77. Summary of estimated exposures due to acoustic sound sources

Species	GOARA	BSAIRA	CSBSRA	Total
Beluga whale - Cook Inlet DPS	3	-	-	**3**
Blue whale - Eastern North Pacific	1	-	-	**1**
Fin whale - Northeast Pacific	36	4	-	**40**
Humpback whale - Central North Pacific Stock	116	45	-	**161**
Humpback whale - Western North Pacific Stock	2	4	-	**6**
North Pacific right whale - Eastern North Pacific	1	1	-	**2**
Bowhead whale - Western Arctic	-	42	-	**42**
Sei whale - Eastern North Pacific	1	1	-	**2**
Sperm whale - North Pacific	3	19	-	**22**
Ringed seal - Arctic Subspecies/Alaska	-	1481	585	**2066**
Bearded seal – Beringia DPS	-	1669	58	**1727**
Steller sea lion – Western DPS	166	51	-	**216**

NMFS manages humpback whales in stocks under the MMPA and as DPSs under the ESA. The probability of encountering whales from each of the four North Pacific DPSs in various feeding areas is summarized in Table 78 below (NMFS 2016e). NMFS used these percentages to calculate the expected number of animals in the two listed DPSs that occur in the action area (Table 78): the endangered Western North Pacific DPS and the threatened Mexico DPS.

Table 78. Probability of encountering humpback whales from each DPS in the North Pacific Ocean (columns) in various feeding areas (on left). Adapted from Wade et al. (2016).

Summer Feeding Areas	North Pacific Distinct Population Segments			
	Western North Pacific DPS (endangered)[1]	Hawaii DPS (not listed)	Mexico DPS (threatened)	Central America DPS (endangered)[1]
Kamchatka	100%	0%	0%	0%
Aleutian I/Bering/Chukchi	4.4%	86.5%	11.3%	0%
Gulf of Alaska	0.5%	89%	10.5%	0%
Southeast Alaska / Northern BC	0%	93.9%	6.1%	0%
Southern BC / WA	0%	52.9%	41.9%	14.7%
OR/CA	0%	0%	89.6%	19.7%

[1]For the endangered DPSs, these percentages reflect the 95% confidence interval of the probability of occurrence in order to give the benefit of the doubt to the species and to reduce the chance of underestimating potential takes.

Table 79. Numbers of humpback whales expected to be part of the listed DPSs that occur in the action area that are expected to be exposed to acoustic noise from research surveys.

Research Area	North Pacific Distinct Population Segments listed under the ESA that occur in the action area		Total number of humpback whales exposed in each research area	Numbers of animals from each DPS		Total number of whales from listed DPSs in each research area
	WNP	Mexico		WNP	Mexico	
GOA	0.5%	10.5%	118	1	13	**14**
BSAI	4.4%	11.3%	49	3	6	**9**
CSBS	4.4%	11.3%	0	0	0	**0**
Total			**167**	**4**	**19**	**23**

Effects of exposure to acoustic noise in Steller sea lion critical habitat

Critical habitat for Steller sea lions is divided into the following zones (50 CFR § 226.202):

- Terrestrial zones that extend 3,000 feet (0.9 km) landward from each major haulout and major rookery in Alaska.
- Air zones that extend 3,000 feet (0.9 km) above the terrestrial zone of each major haulout and major rookery in Alaska.
- Aquatic zones that extend 3,000 feet (0.9 km) seaward of each major haulout and major rookery in Alaska that is east of 144^{o} W longitude.
- Aquatic zones that extend 20 nm (37 km) seaward of each major haulout and major rookery in Alaska that is west of 144^{o} W longitude.
- Three special aquatic foraging areas: the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area, as specified at 50 CFR §226.202(c).

The 20nm aquatic zones and special foraging areas are the only zones that may be affected by acoustic noise from the proposed action. The survey track lines cover a small percentage of these broad zones of critical habitat, and acoustic effects would be temporary in nature. Exposure to acoustic noise inside critical habitat would affect only a very small area and for a very short length of time. NMFS does not anticipate any lasting or significant adverse effects to the physical and biological features of critical habitat from exposure to acoustic noise associated with these research activities.

Effects of exposure to acoustic noise in North Pacific Right Whale critical habitat

The primary constituent elements for the North Pacific right whale critical habitat include the copepods Calanus marshallae, Neocalanus cristatus, and N. plumchris, and the euphausiid Thysanoessa raschii, in areas of the North Pacific Ocean identified in regulation and where North Pacific right whales are known or believed to feed (50 CFR § 226.215).

NMFS anticipates that temporary acoustic noise along track lines that pass through NPRW critical habitat will not affect the availability of species of large zooplankton in areas where right whale are known or believed to feed, which are the primary constituent elements of North Pacific right whale critical habitat.

Effects of exposure to acoustic noise in Cook Inlet Beluga Whale critical habitat

Two of the five physical and biological features identified as essential to the conservation of this DPS could be affected by this proposed action: unrestricted passage within or between the critical habitat areas (the fourth PBF); and waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales (the fifth PBF) (50 CFR § 226.220).

The only potential mechanism through which the AFSC research activities could restrict passage within or between the critical habitat areas per PBF 4 would involve behavioral changes in response to acoustic survey equipment. Similarly, acoustic sources used during AFSC research activities have the potential to result in the temporary displacement of Cook Inlet beluga whales in critical habitat areas per PBF 5.

AFSC surveys use three main active acoustic sources identified as having the largest potential impact to Cook Inlet beluga whale critical habitat, based on their output within the frequency range audible to marine mammals, higher output power, and their operational patterns of use. These sources are the ES60, EK60/ME70, and Reson 7111 acoustic systems. As detailed in Section 6.2.6 of the AFSC LOA application, survey use of the EK60/ME70 or the Reson systems do not overlap with Cook Inlet beluga whales. Further, as shown in Figure 5-3, the bottom trawl surveys (which use ES60) historically have not occurred within the designated critical habitat areas. For the bottom trawl surveys using the ES60, 20 out of 825 (2.4%) stations typically occur in the lower third of Cook Inlet.

Acoustic disturbances associated with the AFSC survey activities are unlikely to isolate parts of the designated critical habitat areas, or prevent movement among sites per PBF 4, since surveys are spread out across large areas of southern Cook Inlet. Elevated noise levels could potentially displace marine mammals from the immediate proximity of the sound source. However, whales will likely return as demonstrated by a variety of studies regarding temporary displacement by more prevalent industrial activity. There is evidence that beluga whales remain in upper Cook Inlet and are not displaced by industrial activity (reviewed in Richardson et al. (1995a)). Beluga whales in Cook Inlet have continued to utilize the habitat in the vicinity of the Port of Anchorage and Knik Arm despite disturbance from maritime operations, maintenance dredging, and aircraft on a daily basis (HDR 2015;(Castellote et al. 2016)). Although the Port of Anchorage area is highly industrialized and supports a large amount of ship traffic, beluga whales are present nearby almost year-round. Despite increased shipping traffic and upkeep operations (e.g., dredging) beluga whales continue to utilize waters within and surrounding the Port of Anchorage where there is frequent tug and cargo ship traffic (Markowitz and McGuire 2007; NMFS 2008a, 2016; HDR 2015).

Therefore, while AFSC research activities may affect PBF 4 or PBF 5, it is apparent that more intensive levels of disturbance have not changed the habitat in ways that cause belugas to stop using it. From research and monitoring of in-water work in Cook Inlet, it does not appear that beluga whales have abandoned habitat areas due to temporary exposures to noise at levels of up to 160 dB (76 FR 20180; April 11, 2011).

6.2.3.2 Exposure to Terrestrial Disturbance from Physical Presence

6.2.3.2.1 Which Listed Species and Critical Habitats may be exposed

Steller sea lion exposure to terrestrial disturbance and the effects of that disturbance on designated Steller sea lion critical habitat are analyzed below. No other species are considered in this analysis because no other listed species (non-Steller sea lion marine mammals and ESA-listed fish species) would be exposed to this stressor.

During surveys conducted near shore, Steller sea lions could be hauled out and at times experience close approaches by survey vessels during the course of fisheries research activities. It is possible that in some areas within the GOARA and BSAIRA, passage of fisheries research vessels may occur within 3 nm (5.6 km) or less of Steller sea lion rookeries and haulouts as the vessels travel to or from research sites and/or while conducting nearshore surveys. Travel and presence within 3 nm of identified Steller sea lion rookeries for research vessels is permitted under 50 CFR 224.103(d)(2)(ii)(B), which states that the Federal government may enter the areas to conduct “legitimate governmental activities.” NMFS researchers take precautions to minimize the frequency and scope of potential disturbances, including choosing travel routes away from hauled out pinnipeds and by moving sample site locations to avoid consistently-used haulout areas whenever possible. However, airborne sounds from research vessel engines, gear deployments, and/or other deck noise may result in disturbance to Steller sea lions on haulouts or rookeries, and sea lions may exhibit a behavioral response to this disturbance (e.g., including flushing, vocalizing, and head alerts) as discussed in the *Response Analysis* (Section 6.3).

NMFS anticipates Level B harassment of Steller sea lions by terrestrial disturbance, according to the chart in Table 80. However, no Level A harassment would be authorized. Level B harassment may include single animals flushing into the water (Level 3 on Table 80) but serious injury or motality could occur if multiple or all hauled out animals stampede into the water trampling pups, and/or if pups become abandoned when nursing mothers leave and do not return because of disturbance. NMFS expects that the mitigation measures included as part of the research activities analyzed in this action will preclude Level A harassment by disturbance.

Behavioral responses may be considered according to the scale shown in

Table 80 and based on the method developed by Mortenson (1996). PR1 considers responses corresponding to Levels 2-3 to constitute Level B harassment. The cause of Level 1 response is impossible to distinguish between normal movement and that caused by disturbance, so Level 1 is not considered Level B harassment.

Table 80. Pinniped response to disturbance

Level	Type of response	Definition
1	Alert	Seal head orientation or brief movement in response to disturbance, which may include turning head towards the disturbance, craning head and neck while holding the body rigid in a u-shaped position, changing from a lying to a sitting position, or brief movement of less than twice the animal's body length.
2	Movement	Movements away from the source of disturbance, ranging from short withdrawals at least twice the animal's body length to longer retreats over the beach.
3	Flight	An animal retreats (flushes) to the water.[1]

[1]This type of response does not include a stampede of multiple animals into the water

6.2.3.2.2 Mitigation to Prevent Disturbance from Physical Presence

Move-on Rule

The move-on rule states that "if any marine mammals are observed around the vessel before setting the gear, the vessel may be moved away from the animals to a different section of the sampling area if the animals appear to be at risk of interaction with the gear." If marine mammals are observed at or near the sampling station, the Chief Scientist (Lead Sampler) and the vessel captain will determine the best strategy to avoid potential takes based on the species encountered; their numbers, behaviors, positions, and vectors relative to the vessel; and other factors.

Survey Site Selection

The selection of survey sites for any given year will include removing stations that could disturb Steller sea lions on rookeries during the pupping and breeding season. The example survey station marked A in Figure 35 is within sight and sound of the part of Marmot Island that is used as a rookery (noted by the thick red line) by Steller sea lions during the pupping and breeding period in late April, May, and June. The station marked B is on the other side of the island and not within sight and sound of the part of the island used as a rookery. In this hypothetical example, terrestrial disturbance of hauled out Steller sea lions at the rookey from research activities at the station marked A could occur. If station A were within 3 nm of the rookery, no survey activity could occur there during between April 20 and June 30, as described in the Mitigation Measures section.

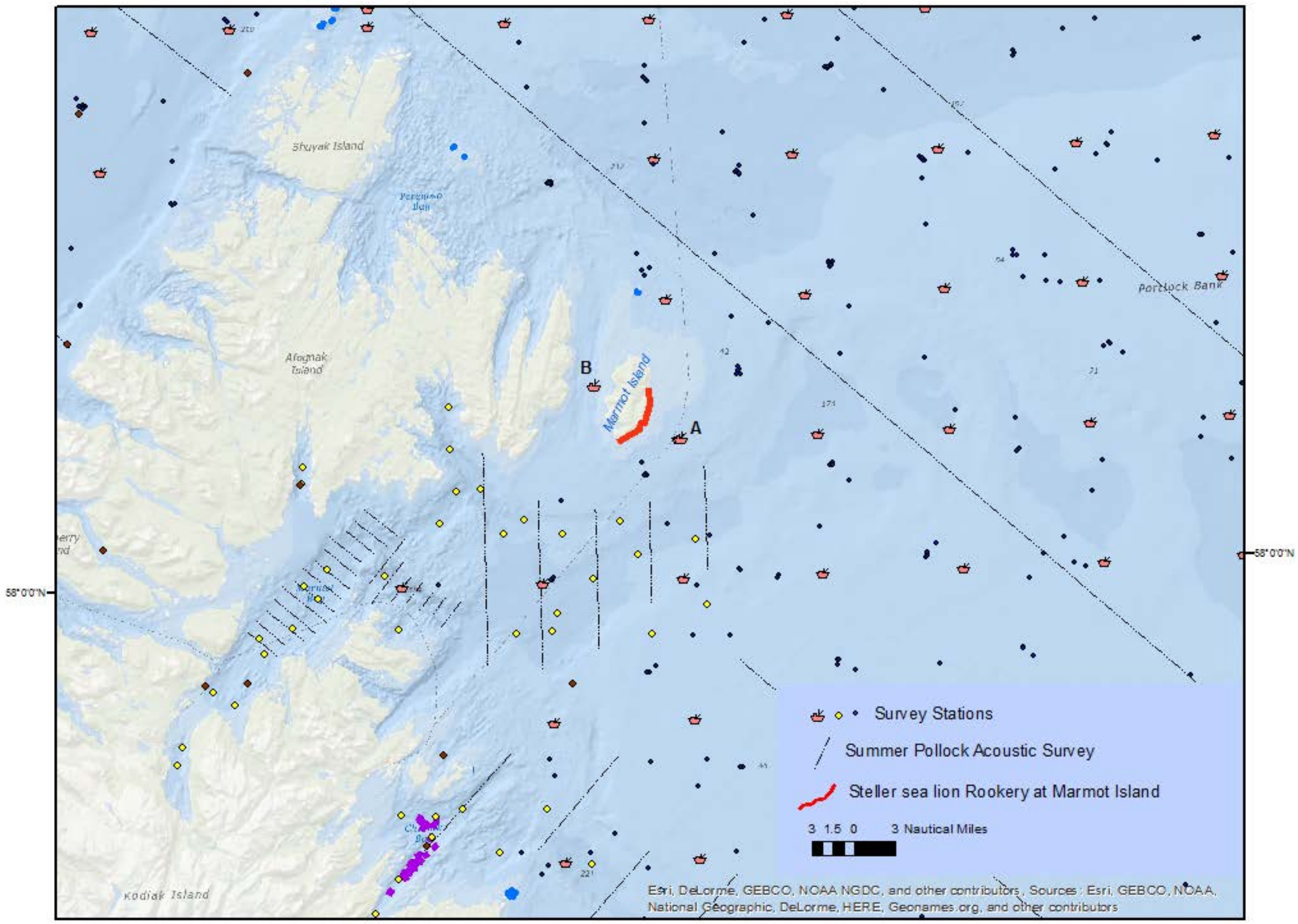

Figure 35. Example survey stations around Marmot Island Steller sea lion rookery.

6.2.3.2.3 Approach to Estimating Exposure to Terrestrial Disturbance from Physical Presence

Level B Harassment of Steller sea lions by terrestrial disturbance was estimated using count data (Fritz et al, 2013) at major haulouts and rookeries (Appendix A) and research survey station and track line locations. If research activity is anticipated within 2 nm of a major rookery or haulout any time of year, all of the individuals at that haulout were assumed to be exposed to terrestrial disturbance.

Exposures were totaled on an annual basis, even though some research activities might occur on an irregular or biennial basis. The annual and total five-year authorization period exposure estimates are shown in Table 81 for each research area. We expect similar levels of interactions to continue into the foreseeable future. No exposure was estimated east of 144°W longitude due to the minimal overlap between AFSC fisheries research activities and known haulouts and rookeries. The IPHC longline survey does occur in Southeast Alaska, but NMFS does not anticipate any Level B harassment because of the distance separating IPHC research locations and rookeries and haulouts: All IPHC research stations are located so that all gear is at a minimum 3 nm from SSL rookeries, and only four stations are within 3nm from haulouts.

6.2.3.2.4 Summary of potential exposure to terrestrial disturbance

Using the methods detailed above, NMFS expects that Steller sea lions could be exposed to Level B harassment while hauled out on rookeries and haulouts from the physical presence of research activities in nearby marine habitat as noted in Table 81. NMFS anticipates this level of exposure to continue into the foreseeable future.

Table 81. Steller sea lion exposure to terrestrial disturbance from the physical presence of researchers in the GOARA and BSAIRA

Species	Estimated Annual exposures	Estimated exposure over 5 yr authorization period
Steller sea lion (Western DPS) in GOARA	3,082	15,410
Steller sea lion (Western DPS) in BSAIRA	112	560
Total Steller sea lion (Western DPS) All areas	**3,194**	**15,970**

6.2.3.2.5 Effects of terrestrial disturbance on Cook Inlet Beluga Whale and North Pacific Right Whale Critical Habitat

We did not analyze terrestrial disturbance on designated critical habitat for Cook Inlet beluga whale and North Pacific right whale because there are no terrestrial components in the PCEs/PBFs for these species.

6.2.3.2.6 Effects of terrestrial disturbance on Steller Sea Lion Critical Habitat

Steller sea lion critical habitat contains several zones (50 CFR § 226.202):

Terrestrial zones that extend 3,000 feet (0.9 km) landward from each major haulout and major rookery in Alaska.

- Air zones that extend 3,000 feet (0.9 km) above the terrestrial zone of each major haulout and major rookery in Alaska.
- Aquatic zones that extend 3,000 feet (0.9 km) seaward of each major haulout and major rookery in Alaska that is east of 144^{o} W longitude.
- Aquatic zones that extend 20 nm (37 km) seaward of each major haulout and major rookery in Alaska that is west of 144^{o} W longitude.
- Three special aquatic foraging areas: the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area, as specified at 50 CFR §226.202(c).

Disturbance of rookeries and haulouts from research activities could potentially affect the terrestrial zones, air zones, and 20 nm aquatic zones around rookeries and haulouts.

Research vessels such as those used for the AFSC Biennial Bottom Trawl Survey for the GOA and AI are often conducting bottom trawls in SSL critical habitats. At any one station, the vessel will approach the station at a speed of 6-8 knots, and then the captain uses the fathometer and attempts to locate sea floor that is smooth enough to tow the research bottom trawl. This process can take up to two hours but is often less than hour. The vessel will then slow down, and the captain will align the vessel with the station and begin to set the gear for approximately 10 minutes. The towing operation typically lasts approximately 30 minutes to 45 minutes depending upon the depth. Once the gear is retrieved, the vessel motors on to the next station at a speed of 8 knots. The entire station occupation process, therefore, lasts approximately 1 to 2 hours. The vessel may transit several miles during this process, but the trawl only occurs over 1.4 km, and the trawl covers a sea floor area of approximately 0.03 square kilometers.

The noises emanating from the vessel are the engine noise muffled through the exhaust system, occasional loud bangs as the doors are released and a secured from the vessel, and sounds of chains or wires being dragged along the deck or sides of the vessel. Human voices are usually obscured by the engine noise but orders may be delivered by the captain. Sound observations on the trawl deck found time-weighed averages were approximately 80 dB or less. As discussed in Section 6.2.3.1.2 above, this level of noise does not rise to the level of harassment as measured by the 100 dB re 20μPa_{rms} standard for in-air exposure. While none of these disturbances is expected to be loud enough to cause either temporary or permanaent hearing damage from acoustic harassment, the noises may cause startle responses and behaviorial disturbance, as discussed earlier.

Mitigation measures including the move-on rule and special Steller sea lion rookery restrictions during breeding and pupping season will eliminate potential disturbance during those critical times.

6.2.4 Exposure to Changes in Habitat

6.2.4.1 Exposure to Competition for Prey Species

The ESA-listed species covered in this Opinion consume a diverse diet of krill, copepods, and various species of fish and invertebrates. AFSC and IPHC research activities remove some of these same species during the course of their work.

Which Listed Species and Critical Habitats may be exposed?

In this section we evaluate the effects of the removal of prey species on the ESA-listed species and designated critical habitat covered in this Opinion. The analysis concentrates on effects to Steller sea lion, North Pacific right whale, and Cook Inlet beluga whale designated critical habitat.

Approach to Estimating overlap between prey species and those removed during research activities

Below, we compare the species removed by research activities to the prey of the listed species in this Opinion. We then evaluate the amount of overlap for the affected species and compare the amount of fish taken during research activities to amounts taken in the commercial fisheries.

Prey of listed species

Marine mammals' selection of prey species can vary by season, life stage, prey size, and location, among other variables, and for some, is not well documented. However, general diet composition is summarized in Table 82. More detailed descriptions are available in the Status of the Species section of this document.

Table 82. Characteristics of listed species covered in this opinion

Common Name	Listed Unit	Functional Hearing Group	Typical Dive Depth (range)	Major Prey Species
Blue Whale	eastern North Pacific Stock	Low frequency cetaceans	100 m[1]	krill
Bowhead Whale	species	Low frequency cetaceans	100 m[1]	Euphausiids & copepods
North Pacific Right Whale	eastern North Pacific Stock	Low frequency cetaceans	-	Large copepods & zooplankton
Fin Whale	northeast Pacific	Low frequency cetaceans	200-250 m[1]	Euphausiids & large copepods
Humpback Whale	Western North Pacific DPS; Mexico DPS	Low frequency cetaceans	170m	Generalized: euphausiids to pollock[2]
Sei Whale	species	Low frequency cetaceans	-	Euphausiids & copepods
Beluga Whale	Cook Inlet DPS	Middle frequency Cetaceans	350m[1]	Seasonal: Eulachon & gadids - salmon[2]
Sperm Whale	species	Middle frequency Cetaceans	1,000m	Squid and other fish species[2]
Bearded Seal	Beringia DPS, Okhotsk DPS	Phocid pinnipeds (true seals)	200m[1]	Bivalve mollusks & crustaceans[2]
Ringed Seal	entire Arctic subspecies	Phocid pinnipeds (true seals)	10-50m	Gadid fishes and invertebrates[2]
Steller Sea Lion	western DPS	Otariid pinnipeds (sea lions and fur seals)	400m[1]	Generalized: cephalopods and fish[2]

[1] Source: http://animaldiversity.org/accounts
[2] At least some prey species are taken in AFSC and IPHC research activities.

Research Activities' Removal of Species

For every species with an average annual research catch greater than 1 mt (metric ton), research activities remove between 0-2.5% of the total allowable catch of those commercially-harvested species (Table 83). The surveys that remove these species are:

- Bering Sea Shelf Bottom Trawl Survey (BSAIRA)
- Aleutian Islands Biennial Shelf and Slope Bottom Trawl Groundfish Survey (BSAIRA)
- Alaska Longline Survey (GOARA and BSAIRA)
- Gulf of Alaska Biennial Shelf and Slope Bottom Trawl Groundfish Survey (GOARA)
- ADFG Large-mesh Trawl Survey of Gulf of Alaska and Eastern Aleutian Islands (GOARA)
- Conservation Engineering (various research activities GOARA and BSAIRA)
- Eastern Bering Sea Upper Continental Slope Trawl Survey Summer (BSAIRA)
- IPHC Fishery-independent Setline Survey (GOARA and BSAIRA)

These surveys are conducted from near-shore to a depth of ~500 meters in the GOARA and BSAIRA and in shallow waters of the CSBSRA (Figure 1). Most research surveys are conducted during the spring and summer although some do extend into the fall (Table 1). Some of the size classes of fish targeted in research surveys are very small (e.g., juvenile salmonids only centimeters long), and these small size classes are not generally targeted by marine mammals. The depth of each survey is also shown in Table 1.

Table 83. Comparison of estimated fish caught during research activities, compared to commercial TAC in the GOA and BSAI (2013-2014 Alaska Groundfish Harvest Specifications), and compared to biomass estimates in the CSBS. Species are listed in descending order of total research catch by weight. Only survey species with average annual research catch greater than one metric ton (1,000 kg) for GOA and BSAI, and 10 kg for CSBS are shown.

Species Group	Stock Status[a]	Species	Average AFSC research catch compared to commercial TAC (percentage)		
			BSAI	CSBS	GOA
Walleye pollock	No overfishing, not overfished	Walleye pollock	0.02%	N/A[f]	0.15%
Arrowtooth flounder	No overfishing, not overfished	Arrowtooth flounder	0.46%	N/A[f]	0.44%
Sablefish	No overfishing, not overfished	Sablefish	0.61%	N/A[f]	2.49%
Grenadiers	Status unknown	Giant grenadier Pacific grenadier	NA	N/A[f]	NA
Pacific cod	No overfishing, not overfished	Pacific cod	0.04%	N/A[f]	0.25%
Flathead sole	No overfishing, not overfished	Flathead sole	0.40%	N/A[f]	0.38%

Species Group	Stock Status[a]	Species	Average AFSC research catch compared to commercial TAC (percentage)		
			BSAI	CSBS	GOA
Pacific ocean perch	No overfishing, not overfished	Pacific ocean perch	0.89%	N/A[f]	0.51%
Shallow-water flatfish	No overfishing, not overfished	Northern rock sole	0.11%	0.30%	0.27%
		Yellowfin sole	0.06%		
		Southern rock sole	0.11%		
		Starry flounder	1.61%		
		Alaska plaice	0.16%		
		Butter sole	-		
		English sole	-		
Longnose skate	No overfishing, overfished status unknown	Longnose skate	-	N/A[f]	0.77%
Dusky rockfish	No overfishing, not overfished	Dusky rockfish	-		0.33%
Thornyhead rockfish	No overfishing, overfished status unknown	Shortspine thornyhead	1.79%	N/A[f]	0.91%
		Longspine thornyhead	-		
Shortraker rockfish	No overfishing, overfished status unknown	Shortraker rockfish	1.44%	N/A[f]	1.07%
Northern rockfish	No overfishing, not overfished	Northern rockfish	1.78%	N/A[f]	0.27%
Rex sole	No overfishing, not overfished	Rex sole	1.61%	N/A[f]	0.14%
Rougheye and Blackspotted rockfish	No overfishing, not overfished	Rougheye rockfish	1.38%	N/A[f]	1.04%
		Blackspotted rockfish	-		
Atka mackerel	No overfishing, overfished status unknown	Atka mackerel	0.31%	N/A[f]	0.46%
Deep-water flatfish	No overfishing, not overfished	Dover sole	-	N/A[f]	0.06%
Big skate	No overfishing, overfished status	Big skate	-	N/A[f]	0.20%
Forage fish species	Status unknown	Eulachon	NA	N/A[f]	2.13%
Forage fish species	Status unknown	Capelin	-	0.45%	-
Other skates	No overfishing, overfished status unknown	Aleutian skate	0.19%	N/A[f]	0.45%
		Bering skate	0.19%		
		Skates unidentified	0.19%		

Species Group	Stock Status[a]	Species	Average AFSC research catch compared to commercial TAC (percentage)		
			BSAI	CSBS	GOA
Sharks	No overfishing, overfished status unknown	Pacific sleeper shark	-	N/A[f]	0.24%
		Spiny dogfish	-		
Other rockfish (silvergray, redbanded, harlequin, sharpchin)	No overfishing, overfished status unknown	-	-	N/A[f]	0.43%
Sculpins	No overfishing, overfished status unknown	Great sculpin	0.28%	N/A[f]	0.13%
		Yellow Irish lord	0.28%		
		Plain sculpin	0.28%		
Demersal shelf rockfish	No overfishing, overfished status unknown	Yelloweye rockfish	-	N/A[f]	0.38%
Arctic cod	Status unknown	Arctic Cod	-	<0.01%	-
Saffron cod	Status unknown	Saffron Cod	-	<0.01%	-
Greenland turbot	No overfishing, not overfished	Greenland turbot	0.57%	-	-
Pricklebacks	Status unknown	Slender eelblenny	-	0.02%	-
Warty sculpin	Status unknown	Warty sculpin	-	<0.01%	-
Bering flounder	Status unknown	Bering flounder	-	<0.01%	-
Arctic staghorn sculpin	Status unknown	Arctic staghorn sculpin	-	<0.01%	-
Alaska plaice	Status unknown	Alaska plaice	-	0.02%	-
Snailfishes	Status unknown	Variegated snailfish	-	<0.01%	-

a. Source: Status of stocks information from NOAA Fisheries Office of Sustainable Fisheries, First Quarter 2015 Status of U.S. Fisheries. Available online: http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries/status_updates.html
b. Some surveys reported number only; estimates of weight were made and included in the total for that species.
c. Source: 2013-2014 Alaska Groundfish Harvest Specification. Available online: https://alaskafisheries.noaa.gov/sustainablefisheries/specs14_15/
d. Spotted ratfish and lingcod are not in the GOA FMP and are not required to have a TAC. Grenadier are considered an “ecosystem component species” in the GOA FMP and are not required to have a TAC because there is no directed commercial fishery.
e. Forage fish, including eulachon, are not required to have an ABC. For this species, the estimated biomass is unknown and the number presented here represents the 2014 estimated catch according to the Alaska Region (http://alaskafisheries.noaa.gov/sustainablefisheries/forage/2014catch.pdf).
f. No biomass estimates is available, and there is no commercial fishery TAC.

Effects of prey removal on listed species

Direct competition between research activities and marine mammals foraging for prey is unlikely for blue, fin, sei, bowhead, and right whales whose diet is 80-100 percent zooplankton, primarily krill or copepods. Humpbacks consume roughly 50 percent large zooplankton, along with small pelagic and miscellaneous fish. Sperm whales consume about 60 percent large squid, and a mix of various fish, small squid, and benthic invertebrates. Listed salmonids and the southern DPS of green sturgeon eat primarily zooplankton and small fishes. The small quantity of potential prey that is removed by the AFSC’s research activities would have a negligible effect on the overall abundance and availability of prey for ESA-listed fish species. Therefore, NMFS does not expect any competition for prey between these ESA-listed marine mammal and fish species and the research activities.

6.2.4.1.1 Effects of prey removal on Ringed and Bearded seals

Research removals of cod and sculpin species are far less than one percent of the estimated biomass in the CSBSRA (Table 83). These small removals are unlikely to have any effect on the availability of prey to ringed and bearded seals. Bearded seals primarily consume crustaceans, which are taken in even smaller numbers by these research activities.

6.2.4.1.2 Effects of prey removal on Steller sea lions, North Pacific Right Whales, and Cook Inlet Beluga Whales

There is overlap between the prey species of wDPS Steller sea lions and Cook Inlet beluga whales and fish species removed by research activities. This overlap is likely further refined by season, depth of the removal, size of fish, time of day of removal, and other variables. NMFS (2010a) reviews why those comparisons are problematic and that the information available to evaluate prey selection by listed species (particularly Steller sea lions) is not available or inconclusive. The effects of this prey removal will be discussed in the critical habitat analysis that follows.

6.2.4.1.3 Effects of prey removal on Cook Inlet Beluga Whale critical habitat

One of the PBFs of designated critical habitat for Cook Inlet belugas is the availability of primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole (PBF 2; 50 CFR § 226.220). Trawl locations are chosen randomly from a grid for the Gulf of Alaska Biennial Shelf and Slope Bottom Trawl Groundfish Survey. While the grid does include some locations that overlap with the southern-most portion of Cook Inlet beluga criticial habitat Area 2, several (typically 1-2) trawl locations may be selected that are inside critical habitat in a given year, and some years would have no overlap (Figure 36). In years with trawl locations inside Area 2, the survey could take some of those species in very small amounts, but the total amount of prey species taken in research surveys is very small relative to their overall commercial and recreational catches and biomass, when known. There are likely no resulting measurable fish population changes because the research catches represent such a small fraction of the total populations of these species. Additionally, this survey takes place in mid-July when Cook Inlet belugas are more likely in Area 1, further away from the mouth of Cook Inlet.

NMFS expects that any reduction in prey availability to Cook Inlet beluga from the proposed research activities would be very small, dispersed in time and geographic area, and likely to have minimal impact on the relevant PBF and on the critical habitat overall.

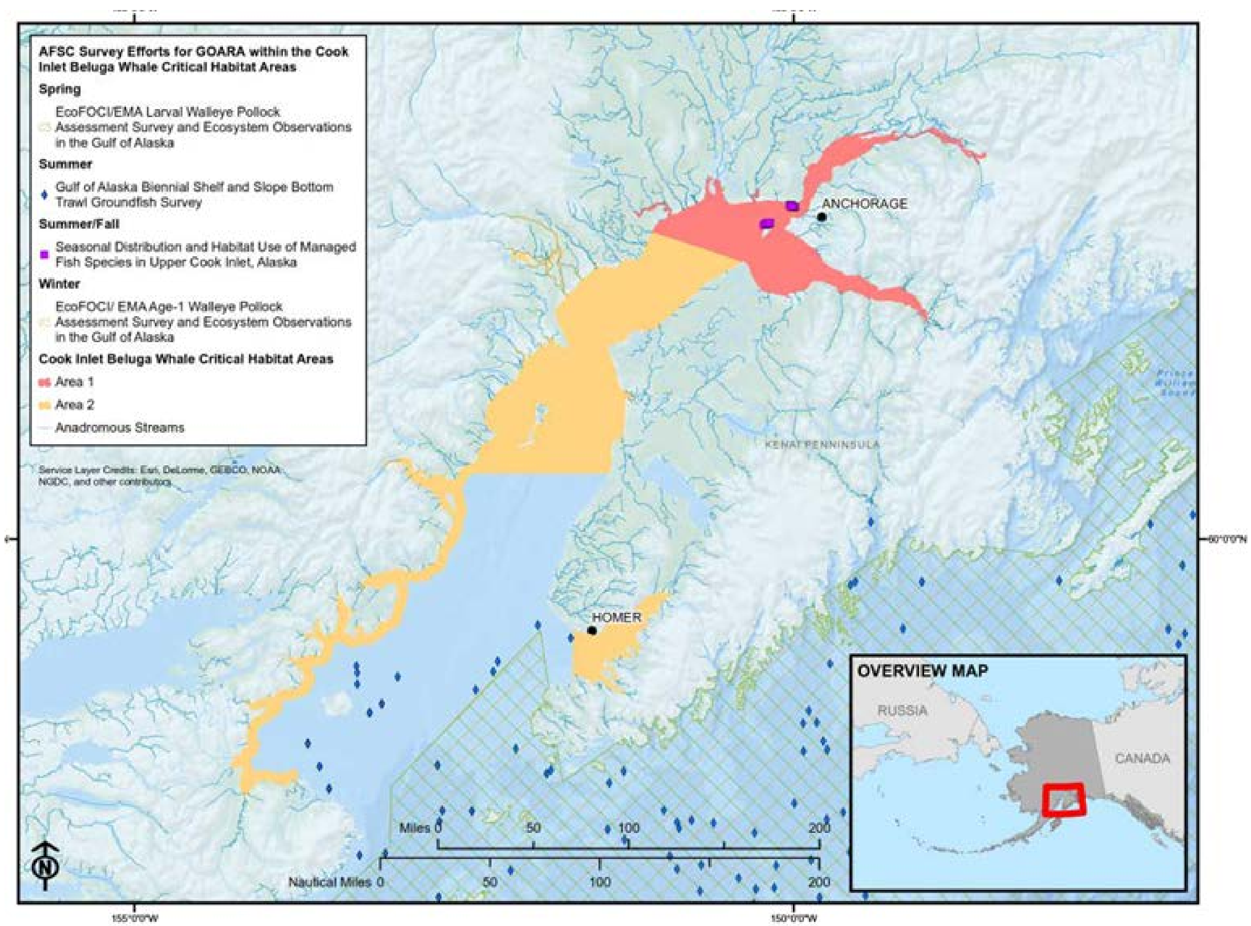

Figure 36. Blue dots symbolize GOA Biennial Shelf and Slope Bottom Trawl Groundfish Survey stations that may harvest Cook Inlet beluga whale prey species. Exact survey stations are drawn randomly each year, so exact locations may change, but these dots represent approximate extent of potential locations. These stations do not overlap Cook Inlet beluga whale designated critical habitat shown in yellow and red.

6.2.4.1.4 Effects of prey removal on North Pacific Right Whale critical habitat

Designated critical habitat for North Pacific right whales includes species of large zooplankton in areas where right whales are known or believed to feed (50 CFR § 226.215).

AFSC fisheries and ecosystem research surveys have very little impact on invertebrate species. The AFSC survey activities occurring in the designated critical habitat area for North Pacific right whale could potentially impact benthic infauna and epifauna as a result of the use of bottom contact equipment. However, pelagic zooplankton that comprise the PBF for North Pacific right whale critical habitat in the eastern Bering Sea and GOA are unlikely to be affected by AFSC survey activities to any measureable extent because the amounts of copepods and other zooplankton that have been identified as the PBFs for the North Pacific right whale affected or removed as a result of the survey activities are very small relative to the overall biomass of the PBF species in the critical habitat areas.

The plankton nets and trawl nets used for AFSC research remove only very small amounts of copepods and other large zooplankton from the North Pacific right whale critical habitat areas.

The Ecosystems & Fisheries-Oceanography Coordinated Investigations (EcoFOCI) surveys described in Table 1 are likely to remove some large zooplankton from the right whale critical habitat areas established in the GOA. Similarly, the Bering Arctic Subarctic Integrated Survey would be likely to remove some copepods and other large pelagic zooplankton from the water column within the areas designated as critical habitat in the Bering Sea. Figure 26 depicts the overlap of AFSC research surveys and North Pacific right whale critical habitat. However, the plankton nets used for these surveys have openings of generally less than $1m^2$ and are capable of removing only small quantities of copepods and other pelagic zooplankton from the critical habitat areas. Other surveys (e.g., trawl and longline) do not target species of large zooplankton and therefore are not expected to restrict or otherwise alter this PCE (of large zooplankton in areas where North Pacific right whales are known or believed to feed) (73 FR 19000; April 8, 2008).

6.2.4.1.5 Effects of prey removal on Steller sea lion critical habitat

Steller sea lion critical habitat is divided into several zones (50 CFR § 226.202):

- Terrestrial zones that extend 3,000 feet (0.9 km) landward from each major haulout and major rookery in Alaska.
- Air zones that extend 3,000 feet (0.9 km) above the terrestrial zone of each major haulout and major rookery in Alaska.
- Aquatic zones that extend 3,000 feet (0.9 km) seaward of each major haulout and major rookery in Alaska that is east of 144° W longitude.
- Aquatic zones that extend 20 nm (37 km) seaward of each major haulout and major rookery in Alaska that is west of 144° W longitude.
- Three special aquatic foraging areas: the Shelikof Strait area, the Bogoslof area, and the Seguam Pass area, as specified at 50 CFR §226.202(c).

Below we analyze the effects of research catch of prey species within these aquatic zones.

Steller sea lions consume several commercially important species that are also taken in fisheries research activities, including Pacific whiting, walleye pollock, Atka mackerel, Pacific herring, capelin, Pacific sand lance, Pacific cod, arrowtooth flounder, rock soles, and salmon (Loughlin 2009, NMFS 2010c, Sinclair *et al.* 2013). Atka mackerel dominates the diet west of Samalga Pass, and walleye pollock dominates east of Samalga Pass (Sinclair *et al.* 2013).

The species of primary concern related to this overlap are walleye pollock, Pacific cod, Atka mackerel, sablefish, salmonids, and small, energy-rich forage fish species such as Pacific sandlance, eulachon, and Pacific herring. However, the total amount of these species taken in research surveys is very small relative to overall commercial and recreational catches and biomass (Table 85). In addition to the small total biomass taken, research catches are also distributed over a wide area because of random sampling designs and other sampling protocols that take small samples within large sample areas. Research tow times are much shorter than commercial tows, and sampling is usually not repeated in the same area.

Table 84 summarizes the average catch of Steller sea lion prey species within designated critical habitat areas in three fisheries management regions. AFSC bottom trawl surveys in the BSAIRA and GOARA remove these prey species.

Table 84. Average annual AFSC fisheries research catch[1] of Steller sea lion prey species within critical habitat in different management areas

Species	Western Aleutians (West of 170°W) RCA 1-5 FMZs 543, 542, 541 (mt per year)	Eastern Aleutians, Western GOA, Bering RCA 6-7 FMZs 500-540, 610 (mt per year)	Central & Eastern GOA RCA 8-10 FMZs 620, 630, part of 640 (mt per year)	Average Catch All Areas Combined (mt per year)
Rockfish	197.5	23.8	20.8	242.0
Walleye pollock	21.8	53.3	24.6	99.7
Atka mackerel	76.3	10.3	<0.1	86.7
Arrowtooth Flounder	7.8	14.3	34.8	56.9
Pacific cod	12.6	14.9	8.0	35.4
Rock soles	7.5	21.6	5.0	34.0
Skates	4.9	3.2	2.6	10.6
Irish Lords	1.7	1.9	<0.1	4.0
Eulachon	-	<0.1	2.2	2.3
Cephalopods	0.5	0.7	0.3	1.5
Sole (other)	-	0.2	0.5	0.6
Pacific herring	-	<0.1	0.4	0.4
Salmon	<0.1	<0.1	0.3	0.4
Smooth lumpsucker	<0.1	<0.1	<0.1	<0.1
Sand lance (unid.)	<0.1	<0.1	<0.1	<0.1
Snailfish	<0.1	<0.1	<0.1	<0.1
Lumpsucker (other)	<0.1	<0.1	<0.1	<0.1
Pacific sandfish	-	<0.1	<0.1	<0.1
Pacific sand lance	-	<0.1	<0.1	<0.1

[1]Catch data are from the following surveys and years: Gulf of Alaska Bottom Trawl Survey (2009, 2012, 2015), Aleutian Islands Triennial Survey (2010), Aleutian Islands Bottom Trawl Survey (2012, 2014), Eastern Bering Sea Shelf Survey (2013, 2014, 2015), and Eastern Bering Sea Slope Survey (2012).

NOTE: AFSC bottom trawl surveys are conducted in each area every other year. These catch data therefore show average catch for years when surveys are conducted; in alternate years catch is zero. The Rookery Cluster Area (RCA) and Fishery Management Zones (FMZs) are relevant to the commercial fishing regulations implementing the Steller Sea Lion Protection Measures (79 FR 70286, 25 November 2014). The AFSC catch is only for areas within Steller sea lion critical habitat; relatively small sampling efforts also occur outside critical habitat areas.

Table 85. Average AFSC fisheries research catch of major SSL prey species in NMFS Reporting Areas 541-543 compared to fishery management metrics (2013-2014 Alaska Groundfish Harvest Specifications)

Species	AFSC average annual catch (mt)	ABC (mt)[1]	AFSC catch compared to ABC	TAC (mt)[2]	AFSC catch compared to TAC
NMFS Reporting Area 541					
Atka mackerel	30.4	21,769	0.14%	21,769	0.14%
Pacific cod	7.2	N/A [3]	N/A [3]	N/A [3]	N/A [3]
Walleye pollock	16.0	11,823.6	0.14%	11,300	0.14%
NMFS Reporting Area 542					
Atka mackerel	29.2	20,685	0.14%	20,685	0.14%
Pacific cod	2.6	N/A 3	N/A 3	N/A 3	N/A 3
Walleye pollock	5.0	5,911.8	0.08%	5,800	0.09%
NMFS Reporting Area 543					
Atka mackerel	39.4	22,023	0.18%	14,315	0.28%
Pacific cod	3.6	1,609 [4]	0.22%	N/A	N/A
Walleye pollock	2.0	1,970.6	0.11%	1,900	0.11%

[1] There are no specific pollock ABC or TACs for each of Areas 541-543, but NMFS sets an overall ABC and TAC for the Aleutian Islands management area and annual area harvest limits for Areas 541-543. The value provided under ABC is given as this harvest limit.
[2] 50 CFR § 679.20(a)(5)(iii)) limits the total maximum Aleutian Islands pollock TAC to 19,000 metric tons (mt), if the ABC equals or exceeds 19,000 mt; if the ABC is less than 19,000 mt, then the TAC can be no greater than the ABC in the 2014-2015 Alaska Groundfish Harvest Specifications.. The pollock TACs for each above area are set at or below ABC.
[3] There are no specific Pacific cod ABCs, TACs, or harvest limits for Areas 541-542. Total Pacific cod ABC for the Aleutian Islands is 15,000 mt and TAC is 6,487 mt. in the 2014-2015 Alaska Groundfish Harvest Specifications.
[4] The value for Pacific cod is a total harvest limit specifically for Area 543, pursuant to 50 CFR § 679.20(a)(7)(vii), which requires NMFS to establish an Area 543 Pacific cod harvest limit based on Pacific cod abundance in Area 543.
NOTE: Bottom trawl surveys are conducted in each area every other year. These catch data therefore show average catch for years when surveys are conducted; in alternate years catch is zero. The AFSC catch is for areas both within and outside sea lion critical habitat, although most catch was within critical habitat. Acceptable Biological Catch (ABC) is a calculated sustainable harvest level based on stock assessment data, and Total Allowable Catch (TAC) is the harvest limit set by fisheries managers based on ABC (and equal to or less than ABC).

Not all species or species groups have established harvest limits or other fisheries metrics with which to compare to AFSC research catches. As an example of the relative size of AFSC fisheries research catch, Table 85 compares average AFSC research catches of three species regulated in the Steller sea lion protection measures to established harvest limits (Total Allowable Catch [TAC]) or fishery metric (Acceptable Biological Catch [ABC]) in the Western Aleutians. Comparing prey species removals during AFSC research surveys to the amount of catch removed during commercial fisheries is problematic because research activities are exempt from the spatial restrictions placed on the commercial fleet. Their research is critical for tracking the abundance and distribution of Steller sea lion prey species both within and outside critical habitat boundaries and assessing the effectiveness of the protection measures. The majority of research catches are within critical habitat areas. Moving stations to accommodate marine mammal occupancy, especially inside critical habitat, presents challenges to survey designs. AFSC conducts surveys and studies with different scientific designs, most notably random and systematic designs. For random surveys, every station in the sampling frame has an equal chance of being selected--once selected, they should be sampled otherwise the chance of selection is altered. For systematic designs, selected stations are sampled each time to maintain the consistency of the time series. When alternate stations are selected or the original station is not conducted, the action compromises the scientific design and the integrity of the survey, for both random and systematic surveys.

Some assumptions and approximations are necessary to make some of these comparisons; see footnotes in the table. For these three species (Atka mackerel, Pacific cod, and walleye pollock), which are the primary prey of Steller sea lions, AFSC fisheries research catches represent a very small fraction of the fisheries metrics and sustainable harvest limits in these areas and are considered minor in magnitude. These low levels of prey removal would be dispersed over large geographic areas and not repeated in the same location annually; research surveys sample in a stratified random design and are generally not conducted in the same area two years in a row. Research tows are also very short in duration, typically 20-30 minutes at depth, so the footprint of each trawl is small.

6.2.4.1.6 Summary of potential exposure to competition for prey

NMFS expects that the amounts of removals from AFSC and IPHC research activities as well as their temporary and dispersed nature across the action area reduce the likelihood of competition for prey to all ESA-listed species and designated critical habitat so as to be considered negligible and discountable.

6.2.4.2 Exposure to changes in water quality, turbidity and contamination from discharges

Discharge from vessels, whether accidental or intentional, includes sewage, ballast water, fuel, oil, miscellaneous chemicals, garbage, and plastics. Impacts to ESA-listed species in the vicinity of the vessel discharges range from superficial exposure to ingestion and related effects. Even at low concentrations that are not directly lethal, some contaminants can cause sub-lethal effects on sensory systems, growth, and behavior of animals, or may be bioaccumulated (DOE 2008).

Which Listed Species and Critical Habitats may be exposed?

Because the action area for this analysis overlaps with the distribution for all ESA-listed marine mammal and fish species and all designated critical habitat in the action area and included in this opinion, they all could be exposed to these stressors.

Mitigation Measures

All NOAA vessels and AFSC chartered vessels are subject to the regulations of MARPOL 73/78, the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 (NOAA 2010), and AFSC instructs its personnel and contractrors to adhere to those requirements. MARPOL includes six annexes that cover discharge of oil, noxious liquid substances, harmful packaged substances, sewage, garbage, and air pollution (IMO 2010). Adherence to these regulations minimizes or negates the likelihood of discharges of potentially harmful substances into the marine environment. Annex V of MARPOL specifically prohibits plastic disposal anywhere at sea and severely restricts discharge of other garbage (IMO 2010).

Conclusions about exposure to these stressors

Discharge of contaminants from AFSC vessels and AFSC chartered vessels is possible, but unlikely to occur any time in the foreseeable future. If an accidental discharge does occur, it is likely to be a rare event, and the potential volume of material is likely to be small and localized. Therefore, the potential impacts to marine mammals would be similarly short-term and localized.

6.3 Response Analysis

As discussed in the *Approach to the Assessment* section of this opinion, response analyses determine how listed species are likely to respond after being exposed to an action's effects on the environment or an action's effects directly on listed species themselves. Our assessments try to detect the probability of lethal responses, physical damage, physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of listed individuals. Ideally, our response analyses consider and weigh evidence of adverse consequences, beneficial consequences, or the absence of such consequences.

6.3.1.1 Entanglement

The response analysis for entanglement includes responses to research gear either wrapped around or ingested by a listed species. On an individual level, the severity of the injury depends on the species and the nature of the entanglement. Injury or mortality will vary based on where and how tightly the gear is wrapped externally on the animal's body, and whether the entanglement resulted in drowning. Other factors include whether ingested gear includes hooks, whether the gear works its way into the gastrointestinal (GI) tract, whether the gear penetrates the GI lining, and the locations of the hooking.

To assess the potential effects of entanglement at the population and species levels, the exposure estimates are evaluated relative to potential biological removal (PBR), which is defined under the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. 16 U.S.C. § 1362(20). Unfortunately, of the four species for which exposures are estimated (sperm whale, western DPS steller sea lion, Beringia DPS bearded seal, and Arctic subspecies ringed seal), PBR is only available for Steller sea lions. Calculations of PBR are stock-specific and include estimates of the minimum population size, reproductive potential of the species, and a recovery factor related to the conservation status of the stock (e.g., whether it is threatened or endangered under the ESA). NMFS is required to calculate PBR (if possible) for each stock of marine mammals over which we have jurisdiction and to report PBR in the annual marine mammal stock assessment reports (SARs) mandated by the MMPA. The PBR metric has been used extensively to assess human impacts on marine mammals in many commercial fisheries involving M&SI and is a recognized and acceptable metric used by NMFS in the evaluation of commercial fisheries incidental takes of marine mammals in U.S. waters as well as for other sources of mortality such as ship strikes.

In spite of some differences between gear, area, timing, and procedures of AFSC research activities and commercial fishing practices, there are enough similarities that it is appropriate to assess the impacts of incidental takes due to research in a manner similar to what is done for commercial fisheries.

Table 86 below compares the AFSC MMPA take request for all gears used in its fisheries research relative to Steller sea lions' PBR. The take for all gears is presented for a five-year period as well as an annual average take for each species with which to compare to the annual PBR values. The average annual take in all gear types and all research areas combined is less than one percent of PBR. This level of mortality, if it occurred, would have no population-level effect on the survival and recovery, as well as reproductive success, of Steller sea lions.

The AFSC take also includes an average of 0.6 "undetermined pinniped" takes per year in trawl gear and 0.4 takes in longline gear. For impact analysis purposes, a percentage of these undetermined takes of western DPS of Steller sea lions have been included. Based on this assumption, take associated with M&SI (i.e., Level A) would still be less than one percent of PBR for the western DPS of Steller sea lions.

NMFS (2008) says that the western DPS of Steller sea lion will be considered for removal from the List when the likelihood of its becoming endangered in the foreseeable future has been eliminated by achieving the following biological criteria: The population for the U.S. region of this DPS has increased (statistically significant) for 30 years (at an average annual growth rate of 3%), based on counts of non-pups (i.e., juveniles and adults). Based on an estimated population size of about 42,500 animals in 2000, this would represent approximately 103,000 animals in 2030.

- The trends in non-pups in at least 5 of the 7 sub-regions are stable or increasing, consistent with the trend observed under criterion #1. The population trend in any two adjacent sub-regions can not be declining significantly. The population trend in any sub-region can not have declined by more than 50%. The 7 sub-regions are:
  a. Eastern Gulf of Alaska (US)
  b. Central Gulf of Alaska (US)
  c. Western Gulf of Alaska (US)
  d. Eastern Aleutian Islands (including the eastern Bering Sea) (US)
  e. Central Aleutian Islands (US)
  f. Western Aleutian Islands (US)
  g. Russia/Asia

This amount of take of western DPS Steller sea lion is not expected to affect the population trend in any of the sub-regions and is not expected to affect the average annual growth rate, therefore the action would not prevent recovery of the species.

While this authorization is for 5 years, NMFS assumes this level of take from research activities will continue into the foreseeable future.

The other three listed species for which entanglement exposure is estimated (sperm whale and ringed and bearded seals) do not have current population data to support calculation of a PBR for the population or DPS. This limits the ability of NMFS to provide a quantitative assessment of the potential impacts of the anticipated exposures of animals from these stocks in fisheries research gear, particularly in the absence of other information, like recovery criteria, that could inform a response analysis. Qualitatively, the average annual take of the other species is less than one animal, which is extremely unlikely to impact these stocks at their current population levels (Table 86).

Table 86. Total annual Level A (M&SI) takes requested for AFSC research by species relative to PBR

Species (Stock)	Total Average Annual Take for All Areas & Gear	PBR	Percent of PBR	Total Annual Take Request with Undetermined Animals	Total Annual Take Request with Undetermined Animals as Percent of PBR
Sperm Whale	0.4	Undetermined	N/A	N/A	N/A
Steller sea lion[1] (Western DPS)	3.6	297	1.2%	4.6	1.5%
Bearded seal	0.4	Undetermined	N/A	N/A	N/A
Ringed seal	0.8	Undetermined	N/A	N/A	N/A

[1]The total requested takes over the five year period for Western DSP Steller sea lions includes 18 Western DPS sea lions for AFSC/IPHC research and 5 undetermined pinnipeds that are conservatively assumed to be Western DPS Steller sea lions.

Take of Listed Fish Species in Research Gear

As evident from Table 62, the vast majority (at least 67%) of salmon originating from the Columbia Basin, Washington coast, and Puget Sound are not listed under the ESA. Of the total abundance for each species, the listed stocks comprise 33% for Chinook, 6% for chum, 5% for coho, and 1% for sockeye. We do not know what proportion of the take would be from each listed salmonid population. We therefore will assume that the likelihood of take is proportional to the abundance of each ESU in relation to the total PNW abundance for the species.

Table 87. Estimated take of ESA-listed Chinook, coho, chum, and sockeye salmon in AFSC, ADFG, and IPHC surveys.

Species and Listing Unit	Average Adult Escapement	Total Take	Percent of Abundance
Non-listed Chinook	427,068	132	0.03%
Puget Sound Chinook	32,481	10	0.03%
Lower Columbia River Chinook	68,061	21	0.03%
Upper Willamette River Chinook	45,896	14	0.03%
Upper Columbia River Spring-run Chinook	9,057	3	0.03%
Snake River Fall-run Chinook	37,812	12	0.03%
Snake River Spring/summer-run Chinook	17,043	5	0.03%
Totals	**637,418**	**197**	**0.03%**
Non-listed Chum	601,231	1,691	0.3%
Hood Canal Summer-run Chum	27,452	77	0.3%
Columbia River Chum	11,070	31	0.3%
Totals	**639,753**	**1,799**	**0.3%**
Non-listed Coho	1,122,217	315	0.03%
Lower Columbia River Coho	56,068	16	0.03%
Totals	**1,178,285**	**331**	**0.03%**
Non-listed Sockeye	336,172	186	0.06%
Snake River Sockeye	1,373	1	0.06%
Ozette Lake Sockeye	2,321	1	0.06%
Totals	**339,866**	**188**	**0.06%**

When compared to the abundance of the ESU (Percent of Abundance), the potential mortality levels are very low: a maximum of 0.3% may be killed from any of the listed salmonids (

Table 63). Furthermore, the effects from all of the research surveys are not likely to disproportionately affect any one population within each ESU. Therefore, examining the four viable salmonid population (VSP) criteria, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

Only 1 Southern DPS Green Sturgeon is expected to be taken during research activities, therefore, the research would likely have no discernible impact on abundance, productivity, spatial structure, or diversity of the DPS.

Because of the low level of historical interactions, as well as the low level of predicted future exposure associated with the use of trawl, longline, and gillnet gear in research activities in the GOARA, BSAIRA, and CSBSRA, NMFS anticipates that these research activities will have no more than a minor impact on annual rates of recruitment or survival of all listed species included in this opinion.

6.3.1.2 Vessel Strike

Numerous studies of interactions between surface vessels and marine mammals have demonstrated that free-ranging marine mammals engage in avoidance behavior when surface vessels move toward them. It is not clear whether these responses are caused by the physical presence of a surface vessel, the underwater noise generated by the vessel, or an interaction between the two (Goodwin and Cotton 2004; Lusseau 2006). However, several authors suggest that the noise generated during motion is probably an important factor (Blane and Jaakson 1994; Evans et al. 1992; Evans et al. 1994b). These studies suggest that the behavioral responses of marine mammals to surface vessels are similar to their behavioral responses to predators.

As we discussed previously, based on the suite of studies of cetacean behavior to vessel approaches (Au and Perryman 1982; Au and Green 2000; Bain et al. 2006; Bauer and Herman 1986; Bejder et al. 1999; Bejder et al. 2006; Corkeron 1995; David 2002; Goodwin and Cotton 2004; Hewitt 1985; Lusseau 2006; Lusseau and Bejder 2007; Magalhaes et al. 2002; Ng and Leung 2003; Nowacek et al. 2001; Richter et al. 2006; Schaffar et al. 2013), the set of variables that help determine whether marine mammals are likely to be disturbed by surface vessels include:

1. *the number of vessels*: The behavioral repertoire marine mammals have used to avoid interactions with surface vessels appears to depend on the number of vessels in their perceptual field (the area within which animals detect acoustic, visual, or other cues) and the animal’s assessment of the risks associated with those vessels (the primary index of risk is probably vessel proximity relative to the animal’s flight initiation distance).

   Below a threshold number of vessels (which probably varies from one species to another, although groups of marine mammals probably share sets of patterns), studies have shown that whales will attempt to avoid an interaction using horizontal avoidance behavior. Above that threshold, studies have shown that marine mammals will tend to avoid interactions using vertical avoidance behavior, although some marine mammals will combine horizontal avoidance behavior with vertical avoidance behavior (Christiansen et al. 2010; Lusseau 2003);

2. *the distance between vessel and marine mammals* when the animal perceives that an approach has started and during the course of the interaction (Au and Perryman 1982; David 2002; Kruse 1991);

3. *the vessel’s speed and vector* (David 2002);

4. *the predictability of the vessel’s path*: That is, cetaceans are more likely to respond to approaching vessels when vessels stay on a single or predictable path (Lusseau 2003; Williams et al. 2002) than when the vessel engages in frequent course changes (Evans et al. 1994a; Lusseau 2006; Williams et al. 2002);

5. *noise associated with the vessel* (particularly engine noise) and the rate at which the engine noise increases, which the animal may treat as evidence of the vessel's speed (David 2002; Lusseau 2003; Lusseau 2006);
6. *the type of vessel* (displacement versus planing), which marine mammals may be interpret as evidence of a vessel's maneuverability (Goodwin and Cotton 2004);
7. *the behavioral state of the marine mammals* (David 2002; Lusseau 2003; Lusseau 2006). For example, Würsig et al. (1998) concluded that whales were more likely to engage in avoidance responses when the whales were 'milling' or 'resting' than during other behavioral states.

Most of the investigations cited earlier reported that animals tended to reduce their visibility at the water's surface and move horizontally away from the source of disturbance or adopt erratic swimming strategies (Lusseau 2003; Lusseau 2006; Williams et al. 2002). In the process, their dive times increased, vocalizations and jumping were reduced (with the exception of beaked whales), individuals in groups move closer together, swimming speeds increased, and their direction of travel took them away from the source of disturbance (Evans et al. 1994b; Kruse 1991). Some individuals also dove and remained motionless, waiting until the vessel moved past their location. Most animals finding themselves in confined spaces, such as shallow bays, during vessel approaches tended to move towards more open, deeper waters (Kruse 1991). We assume that this movement would give them greater opportunities to avoid or evade vessels as conditions warranted.

6.3.1.3 Probable Responses to Entanglement and Vessel Strike

Entanglement and vessel strike may affect listed species. NMFS expects that injury and mortality due to entanglement will cause Level A harassment for Steller sea lions, ringed and bearded seals, and sperm whales by direct interactions as described previously, and so take is authorized in the Incidental Take Statement that follows. Because of the low level of historical interactions, as well as the low level of predicted future exposure associated with the use of trawl, longline, and gillnet gear in research activities in the GOARA, BSAIRA, and the CSBSRA, NMFS anticipates that these research activities will have no more than a minor impact on annual rates of recruitment or survival of all listed species included in this opinion.

Though vessel strike is an ever-present threat when vessels and marine mammals are juxtaposed in space and time, the mitigation measures implemented as part of the research activities reduce that threat enough to be discountable. No take is authorized for any listed species due to vessel strike.

6.3.1.4 ***Acoustic Survey Noise***

Behavioral Responses

The responses that have been measured in a variety of species to audible sounds (see Nowacek et al. (2007) and Southall et al. (2007) for reviews) suggest that the most likely behavioral responses (if any) would be short-term avoidance behavior of the active acoustic sources. To date, there have been no reports or observations of sounds from AFSC fishery research activities disturbing or resulting in behavioral changes in ESA-listed species, although the lack of observations does not necessarily mean no responses have occurred.

Threshold Shifts

Exposure to underwater sound can cause temporary threshold shift (TTS) and/or permanent threshold shift (PTS) in certain conditions. In the *Exposure Analysis* we described the overlap between the sound emitted from research activities and the hearing ranges of listed species. We summarize that information below and describe expected responses by functional hearing groups when there is overlap.

The output frequencies of Category 1 active acoustic sources (>300 kHz) are above the functional hearing range of baleen whales, cetaceans in the mid- and high-frequency hearing groups, and pinnipeds (Figure 32). Because there is no overlap, NMFS does not expect that Category 1 sound sources will affect listed species.

Category 2 output overlaps with sensitive hearing ranges of middle frequency cetaceans (sperm whales and beluga whales), and phocid (ringed and bearded seals) and otariid (Steller sea lions) pinnipeds, but only the upper extremity of the hearing range of the low frequency hearing group (baleen whales) (Figure 32). The sounds most likely to be audible to these hearing groups are of short duration and restricted to areas very close to the research vessel, such as on an active net (net transponders). Therefore, potential interactions are likely to be intermittent and infrequent.

In general, there is a low probability of temporary changes in hearing (masking and possibly temporary threshold shift) from some of the more intense sources in Category 2. Recent measurements by Finneran and Schlundt (2010) of TTS in mid-frequency cetaceans from high frequency sound stimuli indicate a higher probability of TTS in marine mammals for sounds within their region of highest sensitivity. Thus, there is a potential for TTS from some of the category 2 active sources, particularly for mid-frequency cetaceans (and pinnipeds). However, animals would have to be very close (few hundreds of meters) and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (Finneran and Schlundt 2010; Lucke et al. 2009). Given that behavioral responses typically include the temporary avoidance that might be expected, the potential for auditory effects is considered extremely low in relation to realistic operations of these devices. Given the fact that fisheries research survey vessels are moving, the likelihood that animals may avoid the vessel to some extent based on either its physical presence or due to aversive sound (vessel or active acoustic sources), and the intermittent nature of many of these sources, NMFS expects that the potential for TTS is probably very low for all listed species covered in this opinion. Additionally, the potential for exposure to cause physiological damage (injury) is considered extremely low so as to be negligible in relation to realistic operations of these devices. Thus, we conclude here that, on the basis of available information on hearing and potential auditory effects in marine mammals, the potential for TTS and PTS to occur for any species by the acoustic gear from AFSC surveys is discountable in the three research areas.

Masking

Natural and artificial sounds can disrupt behavior by masking, or interfering with, a marine mammal's ability to hear other sounds. Masking occurs when the receipt of a sound is interfered with by another coincident sound at similar frequencies and at similar or higher levels. Chronic exposure to excessive, though not high-intensity, sound could cause masking at particular frequencies for marine mammals that utilize sound for vital biological functions. Masking can interfere with detection of acoustic signals such as communication calls, echolocation sounds, and environmental sounds important to marine mammals. Therefore, under certain circumstances, marine mammals whose acoustical sensors or environment are being severely masked could also be impaired from maximizing their performance fitness in survival and reproduction. If the coincident (masking) sound were anthropogenic, it could be potentially harassing if it disrupted hearing-related behavior. It is important to distinguish TTS and PTS, which persist after the sound exposure, from masking, which occurs only during the sound exposure. Because masking (without resulting in threshold shift) is not associated with abnormal physiological function, it is not considered a physiological effect, but rather a potential behavioral effect.

Masking has the potential to impact species at the population or community levels as well as at individual levels. Masking affects both senders and receivers of the signals and can potentially have long-term chronic effects on marine mammal species and populations. Recent research suggests that low frequency ambient sound levels have increased by as much as 20 dB (more than three times in terms of SPL) in the world's ocean from pre-industrial periods, and that most of these increases are from distant shipping (Hildebrand 2009). All anthropogenic sound sources, such as those from vessel traffic and acoustic noise, contribute to the elevated ambient sound levels, thus intensifying masking.

It is possible that acoustic noise from research activities may mask acoustic signals important to the behavior and survival of marine mammal species, but NMFS expects that the short duration in any one area and the transitory and dispersed nature of the surveys would result in insignificant impacts to listed species from masking.

Summary

Because there is overlap between hearing ranges of listed species and output from acoustic research equipment, Level B harassment could occur, and take of marine mammals by acoustic harassment is authorized in this opinion. The anticipated effects of active acoustic sources used during AFSC research activities on threatened and endangered marine mammals and ESA-listed fish species are likely to occur infrequently, and over a dispersed area. Because of this infrequent and dispersed nature of overlap and likely avoidance behavior by marine mammals, behavioral changes may occur in response to the acoustic noise, but NMFS does not expect any PTS to occur. No Level A harassment from acoustic exposure is authorized in this opinion.

6.3.1.5 Vessel Noise

Continuous noise from survey vessels is expected to be at a very low level and transitory. As described above in relation to acoustic noise from survey gear and the threat of vessel strike, listed species' likely response (if any) to continuous noise from survey vessels would similarly be short-term avoidance behavior of the vessel noise. To date, there have been no reports or observations of sounds from AFSC fishery research activities disturbing or resulting in behavioral changes in ESA-listed species, although the lack of observations does not necessarily mean no responses have occurred.

6.3.1.6 ***Terrestrial disturbance***

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. Behavioral responses to sound are highly variable and context-specific, and reactions, if any, depend on species, state of maturity, experience, current activity, reproductive state, auditory sensitivity, time of day, and many other factors (Richardson et al. 1995a; Southall et al. 2007; Wartzok et al. 2003).

During surveys conducted near shore, Steller sea lions are expected to be hauled out and may be disturbed by research activities. Upon the occurrence of low-severity disturbance (i.e., the approach of a vessel as opposed to an explosion or sonic boom), pinnipeds typically exhibit a continuum of responses, beginning with alert movements and vocalizations (e.g., raising or turning the head), which may then escalate to movement away from the stimulus and possible flushing into the water. Flushed pinnipeds typically re-occupy the haul-out within minutes to hours of the stimulus.

As discussed in the *Exposure Analysis*, for the purposes of this opinion, NMFS does not consider the lesser reactions (e.g., alert behavior and vocalizations) to constitute harassment. NMFS expects that some Steller sea lions will exhibit a more costly behavioral response (e.g., movement and/or flushing) to the visual and auditory stimuli, so estimates of Level B harassment were calculated. NMFS expects that these responses will be infrequent and temporary; however, there is a high level of uncertainty associated with Steller sea lion response to terrestrial disturbance. This uncertainty is largely due to the highly unpredictable nature of disturbed animals. Stimuli from research activities may elicit something as simple as a head turn, or as severe as a stampede (pers. comm Rotterman) depending on:

- Current level of physiological stress right before the disturbance.
- Duration, predictability, repetition, and variation of the stimuli.
- Habituation, when an animal's response to a stimulus wanes with repeated exposure, usually in the absence of unpleasant associated events (Wartzok et al. 2003). Animals are

most likely to habituate to sounds that are predictable and unvarying.

- Sensitization, when an unpleasant experience leads to subsequent responses, often in the form of avoidance, at lowering levels of exposure.
- Behavioral state - for example, animals that are resting may show greater behavioral change in response to disturbing sound levels than animals that are highly motivated to remain in an area for feeding (NRC 2003; Richardson et al. 1995a; Wartzok et al. 2003).
- The physical geometry of the location, which affects visual observation and characteristics of sound sources and their paths (e.g., concentration or dispersal of sound).

The *Exposure Analysis* suggests that 15,970 western DPS Steller sea lions may be exposed to stressors causing Level B harassment while hauled out at rookeries and haulouts over the five year period of this action, and that level of harassment is authorized in the Incidental Take Statement that follows. NMFS expects this level of exposure to continue into the foreseeable future. This is likely an overestimate for several reasons:

- All Steller sea lions counted west of Cape Suckling (144° W longitude) were assumed to be from the western DPS. Eastern DPS animals are known to spend time at rookeries and haulouts in this area, too, so assuming 100% of the counted animals are western DPS is an overestimate.
- Exposures may only be one-time, sporadic, or biennial activities, and may not occur every year as included in the 5-year calculation.
- It is likely many of these animals are not disturbed, but AFSC fisheries researchers have previously not recorded numbers of animals affected by their presence. Until more accurate data becomes available, we conservatively estimate that 100 percent of animals counted at rookeries and haulouts experience Level B harassment when a research vessel comes within 2 nautical miles of a rookery or haulout.
- This highly precautionary approach accounts for the possible event that all animals react to each vessel pass and that multiple vessel passes (i.e., multiple opportunities for disturbance) from different surveys are possible.

Animals that perceive an approaching potential predator, predatory stimulus, or disturbance stimulus have four behavioral options (Blumstein 2003; Nonacs and Dill 1990):

a. ignore the disturbance stimulus entirely and continue behaving as if a risk of predation did not exist;
b. alter their behavior in ways that minimize their perceived risk of predation, which generally involves fleeing immediately;
c. change their behavior proportional to increases in their perceived risk of predation, which requires them to monitor the behavior of the predator or predatory stimulus while they continue their current activity, or
d. take proportionally greater risks of predation in situations in which they perceive a high gain and proportionally lower risks where gain is lower, which also requires them to monitor the behavior of the predator or disturbance stimulus while they continue their current activity.

The latter two options are energetically costly and reduce benefits associated with the animal's current behavioral state. As a result, animals that detect a predator or predatory stimulus at a greater distance are more likely to flee at a greater distance (Lord et al. 2001). Some investigators have argued that short-term avoidance reactions can lead to longer term impacts, such as causing marine mammals to avoid an area (Salden 1988) or altering a population's behavioral budget—time and energy spent foraging versus travelling (Lusseau 2004). These impacts can have biologically significant consequences on the energy budget and reproductive output of individuals and their populations.

The biological significance of many of these behavioral disturbances is difficult to predict, especially if the detected disturbances appear minor. However, the consequences of behavioral modification could be expected to be biologically significant if the change affects growth, survival, or reproduction. Significant behavioral modifications that could potentially lead to effects on growth, survival, or reproduction include:

- Drastic changes in diving/surfacing patterns (such as those thought to cause beaked whale stranding due to exposure to military mid-frequency tactical sonar);
- Habitat abandonment due to loss of desirable acoustic environment; and
- Cessation of feeding or social interaction.

Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators. Close approach by humans, boats, or aircraft caused hauled out sea lions to go into the water, and caused some animals to move to other haulouts during a study in Southeast Alaska (Kucey 2005). Vessels that approach rookeries and haulouts at slow speed, in a manner that sea lions can observe the approach, have less effect than fast approaches and a sudden appearance (NMFS 2011). Sea lions may become accustomed to repeated slow vessel approaches, resulting in minimal response (habituation). Although low levels of occasional disturbance may have little long-term effect, areas subjected to repeated disturbance may be permanently abandoned after sensitization (Kenyon 1962).

Relevant studies of pinniped populations that experience more regular vessel disturbance indicate that population level impacts are unlikely to occur. Some key findings from these studies are summarized below.

In a popular tourism area of the Pacific Northwest where human disturbances were known to occur, past studies observed stable populations of seals over a 20-year period (Calambokidis et al. 1991) despite high levels of seasonal disturbance by tourists using both motorized and non-motorized vessels. Calambokidis et al. (1991) observed an increase in site use (pup rearing) and classified this area as one of the most important pupping sites for seals in the Pacific Northwest. Another study observed an increase in seal vigilance only when vessels passed the haul out site, but then vigilance relaxed within 10 minutes of the vessels' passing (Fox 2008). If vessels frequently occurred within a short time period (e.g., 24 hours), a reduction in the total number of seals present was also observed (Fox 2008).

Based on these studies, repeated disturbance can cause behavioral disturbance and alter normal activity patterns, and as such minimizing these types of disturbances, particularly those that are frequent and prolonged, is important.

However, disturbances resulting from research activities analyzed in this opinion are brief and infrequent and subject to mitigation measures that prevent disturbance during critical pupping periods. NMFS does not expect AFSC activities to result in prolonged or permanent separation of mothers and pups, or to cause such behavioral modification as to adversely affect growth, survival, or reproduction of Steller sea lions.

Sensitivity on Rookeries from late April through the end of June

The possible impacts of various types of disturbance on Steller sea lions have not been well studied, yet the response by Steller sea lions to disturbance will likely depend on season, and their stage in the reproductive cycle (Kucey and Trites 2006). Close approach by humans, boats, or aircraft will cause hauled out Steller sea lions to go into the water, and can cause some animals to move to other haulouts (Calkins and Pitcher 1982; Kucey 2005). Considering that Steller sea lions are likely to not only be present on rookeries from April through June but also breeding or pupping, we expect that disturbance during this period could cause take of breeding adults and/or newborn pups.

Males arrive at rookeries in late April or May to establish a territory. They fast while on the rookery to continue claim on their territory. The effects of flushing a male SSL into the water during this period because of disturbance have not been measured or documented but could include aggressive behavior towards other males to reclaim the rookery, creating an added energetic cost. Male abandonment of that rookery could prevent mating from occurring.

Females arrive at rookeries in May and June to give birth and begin nursing their pup. Females must forage for food for themselves while nursing a pup. The effects of flushing a female Steller sea lion into the water during this period because of disturbance have not been measured or documented but would consume energetic reserves. Repeated disturbances that result in abandonment or reduced use of rookeries by lactating females could negatively affect body condition and survival of pups through interruption of normal nursing cycles. The consequences of such disturbance to the overall population are difficult to measure (NMFS 2010).

6.3.1.7 Probable Responses to Behavioral Harassment

Vessel speed and course changes, sounds associated with engines, deploying survey gear, and conducting research activities, underwater acoustic noise from survey gear, and displacement of water along vessel bowline may all be considered stressors to marine mammals. The Steller Sea Lion Recovery Plan (NMFS 2008) ranked disturbance from these types of sources as a low threat to the recovery of the western DPS. Disturbance from these sources are not likely affecting population dynamics in the western DPS (NMFS 2008).

Vessel noise during transit will likely cause brief, intermittent behavioral responses to all listed species that are not costly to their energy budgets and do not rise to Level B harassment. Level B harassment due to acoustic noise from surveys may cause brief changes to hearing in most of these listed species, but no permanent injury is expected. This analysis authorizes disturbance of hauled out Steller sea lions, using the mitigation measures described in this document.

Disturbance of Steller sea lions on rookeries and haulouts could result in alerts, vocalizing, or flushing behavior, but NMFS expects that mitigation measures and pre-survey planning will reduce exposure to disturbance at rookeries during the critical breeding and pupping period, thereby reducing Steller sea lion response to that stimulus, likely avoiding most Level B harassment and avoiding Level A harassment.

Disturbance would be expected to last for only short periods of time, separated by significant amounts of time in which no disturbance occurred. This level of periodic, infrequent, and temporary disturbance is unlikely to affect use of rookeries and haulouts by Steller sea lions. Because such disturbance is sporadic, rather than chronic, of low intensity, and mitigated to avoid sensitive periods on rookeries, individual marine mammals are unlikely to incur any detrimental impacts to vital rates or ability to forage and, thus, loss of fitness. Correspondingly, local populations, and therefore the overall western DPS, are extremely unlikely to accrue any significantly detrimental impacts.

6.3.1.8 Removal of Prey Species

As discussed in the *Exposure Analysis*, direct competition between research activities and foraging by blue, fin, sei, bowhead, right, humpback, and sperm whales and ringed and bearded seals is unlikely because there is very little overlap between their prey species and the biomass removed by AFSC research activities. Similarly, AFSC research activities remove such small quantities of prey for listed salmonids and southern DPS green sturgeon that any impact from prey removal on these listed fish species is de minimis.

Research activities do remove prey species of Steller sea lions and Cook Inlet beluga whales and therefore affect their designated critical habitat. The effects of this removal are discussed below. The plankton nets and trawl nets used for AFSC research remove only very small amounts of copepods and other large zooplankton from North Pacific right whale critical habitat areas, so NMFS anticipates insignificant effects from this removal.

The Steller sea lion recovery plan (NMFS 2008) ranked competition with commercial fisheries (not research survey activities) as a potentially high threat to the recovery of the western DPS. The Recovery Team determined adult females and juvenile sea lions to be the most vulnerable age-classes to the effects of competition with fisheries. NMFS (2010a) considered that the “most notable indirect effect of commercial fisheries on Steller sea lions is the removal of prey species which could alter the animal's natural foraging patterns and their foraging success rate." However, an independent review determined there was insufficient scientific evidence to support this fishery-driven nutritional stress hypothesis (Bernard et al. 2011).

NMFS (2014) evaluated whether proposed groundfish fisheries were likely to result in local depletions of prey in times and areas that are important to Steller sea lions in the Aleutian Islands where their numbers have declined the most, with an emphasis on adult females in winter and spring. The available data suggest that if nutritional stress is affecting the western DPS it is likely due to localized limitation of important prey resources or low-diet diversity or a combination of the two. The evidence also suggests that the mechanism would be chronic nutritional stress where reduced food resources result in increased maternal investment into juveniles at the expense of high reproduction. However, there are extensive gaps in the available information which prevent understanding the causal relationships affecting Steller sea lions in the western and central Aleutian Islands. In particular, we have the least information about groundfish biomass in winter months when foraging is crucial for adult females.

As a result of that analysis, NMFS (2014) recommended that commercial fisheries catch be dispersed in time and space to prevent localized depletion− at least until such time as we have better local biomass and exploitation rate estimates. The prey removals from the research activities analyzed in this opinion are dispersed by design, so research activities likely do not cause measurable localized depletion or the effects described above. Most surveys that remove Steller sea lion prey species also do not occur in winter months when adult female foraging success is most critical. Most surveys occur in the summer, with the exception of the Atka Mackerel Tag Movement and Abundance study, which tags and recovers fish with bottom trawl to estimate abundance and movement. This survey takes place in the spring, another crucial foraging time for adult females in the Aleutians. Table 85 shows that the total removal of Atka mackerel in the Aleutian Islands is approximately 76 tons per year on average, which compared to the 2013-2014 Harvest Specifications total allowable catch, is less than 0.28% of the total allowable commercial fisheries catch. Foraging Steller sea lions may have to swim past a survey station or wait for fish to come back to their area, but this amount of prey removal in a dispersed area will cause only insignificant effects.

The Gulf of Alaska Biennial Shelf and Slope Bottom Trawl Groundfish Survey takes some Cook Inlet beluga whale prey species in very small amounts, but the survey stations do not directly overlap with Cook Inlet beluga whale critical habitat (Figure 36), and we expect no measurable response from Cook Inlet beluga whales.

6.3.1.9 Changes in water quality and turbidity and contamination from discharges and unauthorized spills

NMFS expects that these potential changes would be small, temporary, and insignificant because the intensity and severity of the effects are so low. Listed species could ingest trace amounts of contaminants and critical habitats may experience temporary changes in water quality, but the overall effects are expected to be very low due to mitigation measures.

6.3.1.10 Probable Responses to Changes in Habitat

Removal of prey, changes in water quality and turbidity, and contamination from discharges and oil spills caused by research activities could cause changes in designated critical habitat for North Pacific right whale, Cook Inlet beluga whale, and Steller sea lions. NMFS expects that these habitat changes would be small, temporary, and insignificant because the intensity and severity of the effects are so low. Similarly, any responses from listed species are likely to be temporary and without significant energy costs to individual animals.

7. CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate change within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the Environmental Baseline (Section 5).

This consultation incorporates a vast action area encompassing the Gulf of Alaska, Bering Sea, Aleutian Islands, Chukchi Sea, and Beaufort Sea. During this consultation, NMFS searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area within the general timeframe of this proposed action. Activities that may occur in this area will likely consist of state, Federal, or foreign government actions related to ocean use policy and management of public resources, such as fishing, oil exploration, or energy development projects. Changes in ocean use policies as a result of government action are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of actions that may occur include development of aquaculture projects; changes to state, Federal, foreign, and international fisheries, which may alter fishing patterns or influence the bycatch of ESA-listed species; changes to vessel traffic; and coastal development, which may also alter patterns of vessel traffic. The activities external to AFSC and IPHC research affecting ESA-listed species will likely continue into the foreseeable future (see Table 5.1-1 in the NEPA analysis). The level of impact will depend on the application and efficacy of current and proposed mitigation measures and the level of direct or indirect effects associated with most of these types of actions. This level of impact appears speculative at this point. Current and continuing non-Federal actions that may continue to occur in the action area and may be affecting ESA-listed species are addressed in the Environmental Baseline section. As a result, we are not aware of any cumulative effects other than those already described in the Environmental Baseline section.

8. INTEGRATION AND SYNTHESIS

The Integration and Synthesis section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 6) to the environmental baseline (Section 5) and the cumulative effects (Section 7) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of both the survival and recovery of the ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) result in the adverse modification or destruction of critical habitat as measured through alterations that appreciably diminish the value of designated critical habitat for the conservation of the species. These assessments are made in full consideration of the status of the species (Section 4).

As we discussed in the *Approach to the Assessment* section of this opinion, we begin our risk analyses by asking whether the probable physical, physiological, behavioral, or social responses of endangered or threatened species are likely to reduce the fitness of endangered or threatened individuals or the growth, annual survival or reproductive success, or lifetime reproductive success of those individuals.

Here we assess the consequences of the responses of the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise. Table 88 is included below to review NMFS determinations as to which stressors are likely to affect which species and the type of impact expected.

Table 88. Stressors, determinations, and take requests associated with this action.

Category of Effect	Stressor	Species Affected	Determination	Critical Habitat Affected	Determination	Level of Take Requested	Key Mitigation Measures
Injury and Mortality	Entanglement	Western DPS Steller sea lion , ringed seals, bearded seals, sperm whales	LAA	n/a	n/a	Level A	Move on Rule, short duration of soak times, weighted longlines
	Vessel Strike	Cook Inlet beluga, North Pacific right, blue, sei, sperm, humpback, fin, and bowhead whales Western DPS Steller sea lion, ringed and bearded seals	NLAA	n/a	n/a	N/A	Move on Rule, humpback whale approach regulations; slow operating speeds
Behavioral Harassment	Impulsive Noise Sources	Cook Inlet beluga, North Pacific right, blue, sei, sperm, humpback, fin, and bowhead whales Western DPS Steller sea lion, ringed and bearded seals	LAA	Steller sea lion North Pacific right whale Cook Inlet beluga whale	LAA	Level B	Move on Rule
	Continuous Noise Sources	Cook Inlet beluga, North Pacific right, blue, sei, sperm, humpback, fin, and bowhead whales Western DPS Steller sea lion, ringed and bearded seals	NLAA	Steller sea lion North Pacific right whale Cook Inlet beluga whale	NLAA	N/A	Move on Rule
	Physical Disturbance	Western DPS Steller sea lion	LAA	Steller sea lion	LAA	Level B	Staying away from rookeries in sensitive period
Changes to Habitat	Removal of Prey Species	Western DPS Steller sea lion, ringed seals, Cook Inlet beluga whale, North Pacific right whale	NLAA	Steller sea lion North Pacific right whale	NLAA	N/A	Dispersed sampling with low total volume

Category of Effect	Stressor	Species Affected	Determination	Critical Habitat Affected	Determination	Level of Take Requested	Key Mitigation Measures
				Cook Inlet beluga whale			
	Changes in water quality and turbidity	Cook Inlet beluga, North Pacific right, blue, sei, sperm, humpback, fin, and bowhead whales Western DPS Steller sea lion, ringed and bearded seals	NLAA	Steller sea lion North Pacific right whale Cook Inlet beluga whale	NLAA	N/A	Short soak times
	Contamination from unauthorized discharges	Cook Inlet beluga, North Pacific right, blue, sei, sperm, humpback, fin, and bowhead whales Western DPS Steller sea lion, ringed and bearded seals	NLAA	Steller sea lion North Pacific right whale Cook Inlet beluga whale	NLAA	N/A	BMPs

8.1 North Pacific Right Whale Risk Analysis

As discussed in the *Status of the Species*, the North Pacific right whale is arguably the most endangered stock of large whale in the world with approximately 31 individuals remaining in the eastern population (Muto et al. 2017). The 2013 North Pacific right whale recovery plan sets criteria for the downlisting and delisting of this species. Both downlisting and delisting criteria include abatement of the threats that limit the continued growth of North Pacific right whale populations including environmental contaminants; reduced prey abundance or location due to climate change; ship collisions; and exposure to anthropogenic noise (NMFS 2013a).

Of these, anthropogenic noise and ship collision are relevant to research activities in this opinion. Although there is spatiotemporal overlap of research activities and the likely distribution of North Pacific right whales, anthropogenic noise associated with this action is not expected to impact the fitness of any individuals of this species, or any other mysticetes. Further, we do not anticipate research vessels will strike any North Pacific right whales due to the mitigation measures in place. Exposure to vessel noise from transit may occur, but adverse effects are likely to be insignificant due to the small marginal increase in such activities relative to the environmental baseline, mitigation measures in place to reduce approach distances, and the transitory nature of the survey vessels.

Downlisting criteria for North Pacific right whales includes the maintenance of at least 1,000 mature, reproductive individuals with at least 250 mature females and 250 mature males in each population (eastern and western). To qualify for downlisting, each recovery population must also have no more than a one percent chance of extinction in 100 years. NMFS expects that research activities will have no effects on the population's progress toward meeting these criteria.

NMFS does not expect instances of Level B harassment to result in fitness consequences for any affected individuals. Because we do not expect fitness consequences for any individual animals, we also do not expect fitness consequences for populations. The two instances of expected harassment could be to the same animal on subsequent days, or be the result of exposures to two or more animals. No injury or mortality is anticipated from the proposed action. While even a single vessel strike could be detrimental to the population, NMFS expects that mitigation measures in place, including vessels slowing inside North Pacific right whale critical habitat whenever any marine mammals are seen, make the risk of vessel strike discountable.

Stressors associated with this action will not affect the population dynamics, behavioral ecology, or social dynamics of individual North Pacific right whales in ways or to a degree that would reduce their fitness. We do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent. Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from research activities conducted for the foreseeable future would not be expected to appreciably reduce the likelihood of the survival and recovery of North Pacific right whales in the wild by reducing the reproduction, numbers, or distribution of that species as currently listed under the ESA.

8.2 North Pacific Right Whale Designated Critical Habitat Risk Analysis

North Pacific Right whale critical habitat contains species of large zooplankton in areas where right whale are known or believed to feed. These feeding areas support a significant assemblage of the remaining North Pacific right whales, and are critical in terms of their conservation value. The risk of vessel strike and pollution from oil spills are threats that may occur inside North Pacific Right whale designated critical habitat. However, mitigation measures decrease the likelihood of vessel strike and pollution associated with this action. NMFS expects that this action will not affect the availability of zooplankton inside North Pacific right whale critical habitat.

Based on our analyses of the evidence available, the quantity and availability of the essential features of designated critical habitat for North Pacific Right whales are not likely to decline as a result of being exposed to research activities analyzed in this opinion. Disturbance consisting of both physical and acoustic effects could temporarily alter the quality of the essential features of designated critical habitats; however, the value of the critical habitat for the conservation of these species will not be appreciably diminished by this action. The size and quality of unaffected critical habitat; the very low, temporary and dispersed impacts to prey resources; and mitigation measures that affect vessel operations allow NMFS to conclude that the proposed action is not likely to destroy or adversely modify the designated critical habitat for North Pacific Right whales.

8.3 Cook Inlet Beluga Whale Risk Analysis

Cook Inlet beluga whales are critically endangered. NMFS estimated the Cook Inlet beluga population to be about 328 animals as of 2016, with a 10-year (2004-2014) declining trend of 0.5 percent per year (Shelden et al. 2017). The 2-6 percent per year recovery that we expected following the discontinuation of subsistence harvest has not occurred. Summer range has contracted steadily since the late 1970s. Whereas Cook Inlet beluga whales formerly made more extensive summer use of the waters off of the Kenai and Kasilof Rivers, they now make little to no use of this salmon-rich habitat during summer salmon runs. This represents a substantial reduction in availability of summer prey. The Susitna River Delta area (including the Beluga and Little Susitna rivers) has become their core summer habitat, with additional high use areas in Knik and Turnagain Arms. Little is known about late fall, winter, or early spring habitat use, although we know that beluga whales make use of the Kenai River when salmon runs (and various salmon fisheries) are not underway. Coastal development, especially near Anchorage, has the potential to disrupt beluga whale behavior, and may alter movements among important summer habitat patches through acoustic disruption (e.g., pile driving may hinder passage to or from Knik Arm from the Susitna Delta area). Boat traffic in the Twentymile River has been documented as having caused behavioral disruption of beluga whales present in the river, while they were presumably feeding there, but the whales fled the river channel to Turnagain Arm when boats encountered them. Seismic exploration in upper Cook Inlet has caused both Level A and Level B takes of Cook Inlet beluga whales. We have no data indicating whether other vessel activities, such as commercial shipping, have caused acoustic harassment of these belugas. Aircraft have been observed to cause behavioral changes in feeding groups of Cook Inlet beluga whales in the Susitna Delta when aircraft circled those groups.

Threats associated with resource development activities such as oil and gas development were considered a factor in the decision to list the species as endangered, but the best available information indicated that these activities were not likely a major contributing factor in the population's decline that preceded the listing (73 FR 62919; October 22, 2008). Oil and gas development in Cook Inlet remains a concern regarding the recovery of the DPS; however, little is known regarding how possible threats, alone or cumulatively, are impacting recovery of the Cook Inlet beluga whale DPS. Though overharvest may have contributed to the massive decline in the 1990s (Hobbs et al. 2000), there is no current subsistence harvest of Cook Inlet beluga whale (Muto et al. 2017).

Due to the location of the planned survey stations, as well as implementation of mitigation measures, exposures to noise at received levels that could cause harassment are expected to be minimal. Data suggest that beluga whales are almost entirely absent from lower Cook Inlet where the research activities will occur during summer months. Exposure to vessel noise from transit may occur, but adverse effects are likely to be insignificant due to the small marginal increase in such activities relative to the environmental baseline, mitigation measures in place to reduce approach distances, and the transitory nature of the survey vessels. Although acoustic noise is likely to cause individual whales to experience changes in their behavioral states that might have adverse consequences to those individual whales (Frid and Dill 2002), NMFS does not expect the 3 anticipated instances (over the five year period) of Level B harassment to alter the physiology, behavioral ecology, or social dynamics of individual whales in ways or to a degree that would reduce their fitness. The three instances of harassment could be to the same animal on subsequent days, or be the result of exposures to three animals. Because we do not expect fitness consequences for any individual animals, we also do not expect fitness consequences for the population. Mitigation measures will reduce exposure of listed species to noise from the action through project timing, and the Move On Rule. Vessel strike could be detrimental to the population, but NMFS expects that mitigation measures in place (including vessels slowing inside critical habitat whenever marine mammals are seen) make the risk of vessel strike discountable. No injury or mortality is anticipated from the proposed action.

Stressors associated with this action will not affect the population dynamics, behavioral ecology, and social dynamics of individual Cook Inlet beluga whales in ways or to a degree that would reduce their fitness. We do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the population those individual whales represent. Based on the evidence available, including the *Environmental Baseline* and *Cumulative Effects*, stressors resulting from research activities conducted for the foreseeable future would not be expected to appreciably reduce the likelihood of the survival and recovery of Cook Inlet beluga whales in the wild by reducing the reproduction, numbers, or distribution of that species as currently listed under the ESA.

8.4 Cook Inlet Beluga Whale Designated Critical Habitat Risk Analysis

Designated critical habitat for the Cook Inlet beluga includes five PBFs essential to the conservation of the species: intertidal and subtidal waters of Cook Inlet with depths <30 feet and within five miles of high and medium flow anadromous fish streams; primary prey species; waters free of toxins or other agents of a type and amount harmful to Cook Inlet beluga whales; unrestricted passage within or between critical habitat areas; and waters with in-water noise below levels resulting in the abandonment of critical habitat areas by Cook Inlet beluga whales (50 CFR §226.220(c)). Threats to beluga whales of high and medium concern that may impact critical habitat include: catastrophic events such as oil spills, noise, habitat loss or degradation, and reduction in prey (NMFS 2016f).

Based on our analyses of the evidence available, the quantity and availability of the essential features of designated critical habitat for Cook Inlet Beluga whales are not likely to decline as a result of being exposed to research activities analyzed in this opinion. Disturbance consisting of both physical and acoustic effects could temporarily alter the quality of the essential features of designated critical habitats; however, the value of the critical habitat for the conservation of these species will not be appreciably diminished by this action. The size and quality of unaffected critical habitat; the very low, temporary and dispersed impacts to prey resources; and mitigation measures applied to vessel operations, including in critical habitat, allow NMFS to conclude that the proposed action is not likely to destroy or adversely modify the designated critical habitat for Cook Inlet beluga whales.

8.5 Sperm Whale Risk Analysis

The 2010 sperm whale recovery plan defines three recovery populations by ocean basin (the Atlantic Ocean/Mediterranean Sea, Pacific Ocean, and Indian Ocean) and sets criteria for the downlisting and delisting of this species. The Pacific stock occurs in Alaska waters, but no population trend is available. Both downlisting and delisting requirements include abatement of threats associated with vessel collisions, reduced prey abundance due to climate change, the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates, contaminants and pollutants, and, possibly, the effects of increasing anthropogenic ocean noise.

Of these, anthropogenic noise and vessel collision are relevant to research activities. There is spatiotemporal overlap of research activities and the likely distribution of sperm whales.

Exposure to vessel noise from transit may occur, but adverse effects are likely to be insignificant due to the marginal increase in such activities relative to the environmental baseline, mitigation measures in place to reduce approach distances, and the transitory nature of the survey vessels. NMFS expects up to 22 Level B harassment instances due to acoustic noise from research activities, but noise associated with this action is not expected to impact the fitness of any individuals of this species. Further, we do not anticipate research vessels will strike any sperm whales due to the mitigation measures in place. Sperm whales may experience entanglement with fishing gear during research activities, particularly longline surveys. NMFS estimates that up to 2 sperm whales may suffer M&SI over the five-year period and that same level of M&SI may continue into the foreseeable future.

Downlisting criteria for sperm whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a 1 percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years. NMFS expects that research activities will have no effects on the population's progress toward meeting these criteria.

Stressors associated with this action will not affect the population dynamics, behavioral ecology, and social dynamics of individual sperm whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent. We do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated. Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that stressors resulting from research activities would not be expected to appreciably reduce the likelihood of the survival and recovery of sperm whales in the wild by reducing the reproduction, numbers, or distribution of that species.

8.6 Mexico and Western North Pacific DPS Humpback Whale Risk Analysis

Humpback whales were greatly threatened by commercial whaling in the past. Today threats include predation, disease and parasites, entanglement, vessel strike, habitat degradation, and anthropogenic noise. Population trends for the Mexico and Western North Pacific DPSs are unknown.

Based on the results of the exposure analysis, we expect a total of 167 humpback whales may be exposed to noise from the proposed acoustic surveys, but only 4 of those are likely from the Western North Pacific DPS and 19 of those are likely from the Mexico DPS. Exposure to vessel noise from transit may occur, but adverse effects are likely to be insignificant due to the marginal increase in such activities relative to the environmental baseline, mitigation measures in place to reduce approach distances, and the transitory nature of the survey vessels. NMFS considers the risk of vessel strike to be discountable because of the implementation of mitigation measures to reduce speed and approach distances. NMFS expects only small, temporary changes to habitat used by humpback whales. These reactions, behavioral changes, and changes to habitat are expected to subside quickly when the exposures cease.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of humpback whales. As discussed in the *Description of the Action* and *Status of the Species* sections, this action does not overlap in space or time with humpback whale breeding. Mexico DPS humpback whales feed in the action area in the summer months, but migrate to Mexican waters for breeding and calving in winter months. Western North Pacific DPS humpback whales feed in the action area in the summer months, but migrate to waters off southeast Asia for breeding and calving in winter months. As a result, the probable responses to acoustic survey and continuous vessel noise combined with minor reactions from changes in water quality are not likely to reduce the current or expected future reproductive success of Mexico or Western North Pacific DPS humpback whales or reduce the rates at which they grow, mature, or become reproductively active.

Stressors associated with this action will not affect the population dynamics, behavioral ecology, and social dynamics of individual humpback whales in ways or to a degree that would reduce their fitness. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent. We do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated. Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that stressors resulting from research activities would not be expected to appreciably reduce the likelihood of the survival and recovery of humpback whales in the wild by reducing the reproduction, numbers, or distribution of that species.

8.7 Blue, Sei, Fin, and Bowhead Whales Risk Analysis

We have combined the risk analysis for blue, sei, fin, and bowhead whales due to their similar exposure to stressors in this opinion.

Recent evidence indicates that the Eastern North Pacific blue whale population has likely reached carrying capacity (Monnahan et al. 2014). Research activities, commercial fishing, and other vessel-based activities have been occurring where this population occurs for decades. Therefore, any potential impacts from research activities on blue whales do not appear to have inhibited growth of the Eastern North Pacific blue whale population.

The 1998 blue whale recovery plan does not outline downlisting or delisting criteria. The recovery plan does list several stressors potentially affecting the status of blue whales in the

North Pacific Ocean that are relevant to research activities including: vessel strike, vessel disturbance, and military operations (including sonar). At the time the recovery plan was published, the effects of these stressors on blue whales in the Pacific Ocean were not well documented, their impact on recovery was not understood, and no attempt was made to prioritize the importance of these stressors on recovery. As described previously, anthropogenic noise associated with research activities is not expected to impact the fitness of any individuals of this species. No mortality of blue whales is expected to occur from the proposed activities.

The 2011 sei whale recovery plan defines three recovery populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Both downlisting and delisting requirements include abatement of threats associated with vessel collisions, entanglement in active or derelict fishing gear, reduced or displaced prey abundance due to climate change, the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates, and the effects of increasing anthropogenic ocean noise. Of these, anthropogenic noise, entanglement, and vessel strike are relevant to research activities, although NMFS does not expect or authorize take for entanglement of sei whales. Downlisting criteria for sei whales includes the maintenance of 1,500 mature, reproductive individuals with at least 250 mature females and 250 mature males in each ocean basin. To qualify for downlisting, each recovery population must also have no more than a 1 percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years.

The 2010 fin whale recovery plan defines three populations by ocean basin (the North Atlantic, North Pacific, and Southern Hemisphere) and sets criteria for the downlisting and delisting of this species. Under the MMPA, NMFS manages three stocks of fin whale in the North Pacific: 1) the Hawaii stock; 2) the California/Oregon/Washington stock, and 3) the Alaska stock (Carretta et al. 2017). Both downlisting and delisting requirements include abatement of threats associated with vessel collisions, reduced prey abundance due to overfishing and/or climate change, the possibility that illegal whaling or resumed legal whaling will cause removals at biologically unsustainable rates and, possibly, the effects of increasing anthropogenic ocean noise. Of these, anthropogenic noise and ship collision are relevant to research activities. Downlisting criteria for fin whales includes the maintenance of at least 250 mature females and 250 mature males in each recovery population, which is already exceeded in the North Pacific. To qualify for downlisting, each recovery population must also have no more than a 1 percent chance of extinction in 100 years. To qualify for delisting, each recovery population must also have no more than a 10 percent chance of becoming endangered in 20 years.

The International Whaling Commission (IWC) recognizes four stocks of bowhead whales for management purposes (Muto et al. 2017). The Western Arctic stock of bowhead whale is the only stock to inhabit U.S. waters (Muto et al. 2017). There is no recovery plan for bowhead whales, however threats to recovery likely include entanglement in active or derelict fishing gear, reduced or displaced prey abundance due to climate change, and vessel collisions and increasing anthropogenic ocean noise associated with Arctic oil and gas development. Of these, anthropogenic noise, entanglement, and vessel strike are relevant to research activities, although NMFS does not expect or authorize take for entanglement of bowhead whales.

NMFS expects that blue, sei, fin, and bowhead whales may also be adversely affected by exposure to acoustic noise as a result of the research activities. As many as 1 blue, 2 sei, 48 fin, and 42 bowhead whales may experience Level B harassment from acoustic sounds due to the proposed action. No whales are anticipated to be exposed to sound levels that could result in TTS or PTS, and no mortality or serious injury is expected or authorized. Note that NMFS does not expect any Level B harassment of low-frequency cetaceans in the CSBSRA because the acoustic sources used in that area are out of the hearing range for those species. These estimates represent the total number of takes that could potentially occur, over five years and into the foreseeable future, but not necessarily the number of individuals taken, as a single individual may be taken multiple times over the course of the proposed action. These take estimates are likely to be overestimates because the estimates assume a uniform distribution of animals in the action area (and takes are rounded up to whole animals), and mitigation measures may further reduce exposure.

Exposure to vessel noise, changes in water quality, contamination, and the risk of vessel strike may occur, but the expected effects are considered minimal and would not likely result in take. Vessel strike is extremely unlikely to occur due to mitigation measures, so NMFS considers that risk discountable.

The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). Large whales such as fin and humpbacks have an ability to store substantial amounts of energy, which allows them to survive for months on stored energy during migration and while in their wintering areas, and their feeding patterns allow them to acquire energy at high rates. The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of these whales (i.e., reduce the amount of time they spend at the ocean's surface, increase their swimming speed, change their swimming direction to avoid research operations, change their respiration rates, increase dive times, reduce feeding behavior, or alter vocalizations and social interactions) and their probable exposures to noise sources are not likely to reduce their fitness or current or expected future reproductive success or reduce the rates at which they grow, mature, or become reproductively active. Therefore these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent.

Research activities may cause some individual whales to experience changes in their behavioral states that might have adverse consequences to those individual whales (Frid and Dill 2002).

However, these responses are not likely to alter the physiology, behavioral ecology, and social dynamics of individual whales in ways or to a degree that would reduce their fitness because it is anticipated that the whales will continue to actively forage in waters around the survey stations or will seek alternative foraging areas. An action that is not likely to reduce the fitness of individual whales would not be likely to reduce the viability of the populations those individual whales represent. We do not anticipate any reductions in survival rate or trajectory of recovery of the species as listed pursuant to the ESA that could be readily perceived or estimated. Based on the evidence available, including the environmental baseline and cumulative effects, we conclude that stressors resulting from the proposed research activities would not be expected to appreciably reduce the likelihood of the survival and recovery of fin, blue, sei, and bowhead whales in the wild by reducing the reproduction, numbers, or distribution of those species.

8.8 WDPS Steller Sea Lion Risk Analysis

The 2016 Stock Assessment Report for the western DPS of Steller sea lions indicates a minimum population estimate of 50,983 individuals (Muto et al. 2017). Data collected through 2015 indicate an increase of about 2% per year in non-pup and pup counts of the western DPS between 2000 and 2015. This trend varies by region, with positive trends in the eastern portion of their range and negative trends further west in the Aleutian Islands (Muto et al. 2017).

The Steller sea lion recovery plan (NMFS 2008) lists recovery criteria that must be accomplished in order to downlist the western DPS from endangered to threatened and to delist the western DPS. These criteria generally include an increased overall population size, requirements that any two adjacent sub regions cannot be declining significantly, reducing the threats to sea lion foraging habitat, and reducing intentional killing and overutilization. NMFS concludes that western DPS Steller sea lion response from the proposed activities will not impede progress towards these recovery criteria due to the anticipated Level A and B harassment, and no significant effects to habitat. NMFS recognizes that these anticipated levels of harassments are conservative and likely overestimates that will be refined when additional information is available in future analyses.

Based on the results of the exposure analysis for the proposed activities, we expect a maximum of 23 Western DPS Steller sea lions may be taken by Level A harassment caused by gear entanglement, 218 may be taken by Level B harassment caused by acoustic noise, and 15,970 may be taken by Level B harassment cause by terrestrial disturbance in the next five years, and similar levels of harassment will occur into the foreseeable future. Disturbance from vessel noise, potential for vessel strike, prey removal, and habitat contamination may occur as a result of the proposed activities, but adverse effects to Steller sea lions are likely to be insignificant due to the marginal increase in such activities relative to the environmental baseline and mitigation measures associated with this action.

Steller sea lions' probable response to terrestrial disturbance and exposure to acoustic noise includes brief startle reactions or short-term behavioral modification. These reactions and behavioral changes are expected to subside quickly when the exposures cease. NMFS anticipates that the numbers of Steller sea lions that experience terrestrial disturbance will be likely much lower, and mitigation measures will protect animals hauled out on rookeries during critical mating, pupping, and nursing periods. The primary mechanism by which the behavioral changes we have discussed affect the fitness of individual animals is through the animal's energy budget, time budget, or both (the two are related because foraging requires time). The individual and cumulative energy costs of the behavioral responses we have discussed are not likely to reduce the energy budgets of Steller sea lions. The small numbers of Steller sea lions entangled in research gear is likely less than one percent of PBR for the western DPS of Steller sea lions, and therefore unlikely to affect population trends. NMFS does not anticipate any effects from this action on the reproductive success of the western DPS of Steller sea lions.

Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent. While a single individual may be exposed multiple times during the project, both the short duration of actual sound generation and the implementation of mitigation measures to reduce exposure to high levels of sound reduce the likelihood that exposure would cause a behavioral response that may affect vital functions, or cause TTS or PTS. Cumulative effects of future state or private activities in the action area are likely to affect Steller sea lions at a level comparable to present. The current and recent population trends for Western DPS Steller sea lions vary by region. In most regions, growth indicates that these levels of activity are not hindering population growth. The Western Aleutian Islands sub-region is still experiencing declines, and the effects of anthropogenic activities in this remote area are poorly understood with a great deal of uncertainty surrounding Steller sea lion responses to disturbance.

Because of the small numbers of Level A takes, low intensity of behavioral effects, and mitigation measures in place, NMFS expects that this project is not likely to appreciably reduce western DPS Steller sea lions' likelihood of surviving and recovering in the wild by reducing the reproduction, numbers, or distribution of the species.

8.9 WDPS Steller Sea Lion Designated Critical Habitat Risk Analysis

Research activities may overlap with all of the PBFs of Steller sea lion critical habitat as described in Section 4.2.1.1.

The primary threats that could affect the features identified as essential to conservation of Steller sea lions include: wildlife viewing, boat and aircraft traffic, research activities, commercial, recreational and subsistence fishing, timber harvest, hard mineral extraction, oil and gas development, coastal development, including pollutant discharges, and subsistence harvest.

Based on our analyses of the evidence available, the quantity and availability of the essential features of designated critical habitat for Western DPS of Steller sea lions are not likely to decline as a result of being exposed to research activities analyzed in this opinion. Disturbance consisting of both physical and acoustic effects could temporarily alter the quality of the essential features of designated critical habitats; however, the value of the critical habitat for the conservation of these species will not be appreciably reduced by this action. The size and quality of unaffected critical habitat; the very low, temporary and dispersed impacts to prey resources; and mitigation measures applied to vessel operations allow NMFS to conclude that the proposed action is not likely to destroy or adversely modify the designated critical habitat for Western DPS Steller sea lions.

8.10 Ringed and Bearded Seals Risk Analysis

Recovery plans have not yet been developed for ringed and bearded seals listed as threatened under the ESA, however abundant ice-based habitat is of primary importance to the future of these species. Fewer research activities occur in the CSBSRA than in the other research areas, so fewer surveys may interact with these Arctic species. Research activities will have no effect on the ice-based habitat necessary to the survival of these species.

Ringed and bearded seals may experience entanglement with fishing gear and may be exposed to Level B harassment from acoustic noise associated with this action. NMFS estimates that up to 2 bearded seals and 4 ringed seals may suffer M&SI over the five-year period and up to 2,102 ringed seals and 1,768 bearded seals may be exposed to acoustic noise as a result of research activities over the five-year period. NMFS expects similar rates of interactions and exposure to continue into the foreseeable future. Disturbance from vessel noise, potential for vessel strike, prey removal, and habitat contamination may occur as a result of the proposed activities, but adverse effects to ringed and bearded seals are likely to be insignificant due to the marginal increase in such activities relative to the environmental baseline and mitigation measures associated with this action.

The numbers of seals taken in fishing gear are insignificant compared to the best available population estimates for these species. Therefore, these exposures are not likely to reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent. Cumulative effects of future state or private activities in the action area are likely to affect ringed and bearded seals at a level comparable to present. As a result, NMFS expects that this project is not likely to appreciably reduce ringed or bearded seals’ likelihood of surviving and recovering in the wild by reducing the reproduction, numbers, or distribution of the two species.

8.11 Salmonids Risk Analysis

As described in the *Environmental Baseline* (Section 5), NMFS has consulted on the effects of fisheries research conducted and funded by the SWFSC and NWFSC, the issuance of a LOA under the MMPA for the incidental take of marine mammals pursuant to those research activities, and the issuance of scientific research permits under the ESA for directed take of ESA-listed salmonids (NMFS 2015a; NMFS 2016c). The following two tables combine the proposed take for all the actions considered in this opinion, with the take previously authorized in the

SWFSC and NWFSC biological opinions (Table 89), and then compare those totals to the estimated annual abundance of each species under consideration (Table 90).

Table 89. Total expected take of the ESA-listed species authorized in the SWFSC and NWFSC biological opinions plus the activities covered in this biological opinion for AFSC and IPHC research activities. "Baseline" take of these species, as listed below, is covered in other biological opinions and included in the environmental baseline of this analysis.

Species and Listing Unit	Life Stage	Baseline Lethal Take (SWFSC and NWFSC)	Annual Lethal Take Requested by AFSC	Combined Lethal Take
Puget Sound Chinook	Adult	46	10	56
Lower Columbia River Chinook	Adult	18	21	39
Upper Willamette River Chinook	Adult	15	14	29
Upper Columbia River Spring-run Chinook	Adult	9	3	12
Snake River Fall-run Chinook	Adult	14	12	26
Snake River Spring/summer-run Chinook	Adult	9	5	14
Hood Canal Summer-run Chum	Adult	9	77	86
Columbia River Chum	Adult	9	31	40
Lower Columbia River Coho	Adult	49	16	65
Snake River Sockeye	Adult	8	1	9
Ozette Lake Sockeye	Adult	8	1	9

Table 90. Take authorized in the combined SWFSC/NWFSC biological opinion and in the AFSC biological opinion compared to the estimated annual abundance of each species under consideration.

Salmonid ESU/DPS	Life Stage	Average Adult Escapement	Combined Lethal Take	Percent of Abundance
Puget Sound Chinook	Adult	32,481	56	0.2%
Lower Columbia River Chinook	Adult	68,061	39	0.06%
Upper Willamette River Chinook	Adult	45,896	29	0.06%
Upper Columbia River spring Chinook	Adult	9,057	12	0.1%
Snake River fall Chinook	Adult	37,812	26	0.07%
Snake River spring/summer Chinook	Adult	17,043	14	0.08%
Columbia River chum	Adult	27,452	86	0.3%
Hood Canal summer-run chum	Adult	11,070	40	0.4%
Lower Columbia River coho	Adult	56,068	65	0.1%
Ozette Lake sockeye	Adult	1,373	9	0.6%
Snake River sockeye	Adult	2,321	9	0.4%

For the eleven salmonid ESUs potentially affected by this research, the lethal take proposed by the activities included in this opinion represents no more than 0.4% of the estimated abundance even when combined with the SWFSC and NWFSC research take that has already been authorized. Furthermore, the effects of the losses would be small, and because they would not be expected to disproportionately affect any one population within an ESU, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population).

Moreover, the research authorized in these opinions causes only small reductions in abundance and productivity while providing benefits for science and management, including information that can be used to manage salmon and steelhead originating from the West Coast Region and salmon off Alaska.

In summary, we conclude that the level of incidental and directed take of salmonids during AFSC, ADFG, and IPHC research activities each year that has been proposed and considered in this opinion, particularly in terms of potential mortality, represents a very small reduction in abundance that is not likely to significantly impact any ESA-listed salmonids over time. We also conclude that the diversity of ESA-listed salmonid populations will be not be affected by this limited amount of take that should be distributed across populations throughout salmonid ranges in the ocean. We have generally identified and considered the worst case scenario of potential mortality for each ESA-listed salmonid population considered in this opinion, where applicable, leading to the most conservative estimates of expected take. As described in the opinion, it is likely that capture and mortality totals for each ESA-listed salmonid population will be some fraction less than the conservative estimates generated in the opinion.

We have concluded that the proposed action will have a very small effect on the species' abundance and productivity, but will not affect population structure or diversity at all. When the effect of this proposed action is added to the status, environmental baseline, and cumulative effects of other activities, and the anticipated effects of climate change over the foreseeable future, there is no increase in the risks of extinction or impediments to recovery for any of these ESA-listed species. As a result, we conclude that the proposed action will not appreciably reduce the likelihood of survival and recovery, by reducing the reproduction, numbers, or distribution, of any of the eleven ESA-listed salmonids that may be affected by this proposed action.

8.12 Southern DPS Green Sturgeon Risk Analysis

For the listed green sturgeon, there is no request for, nor do we anticipate, any mortality from the action considered in this biological opinion. Furthermore, there was no green sturgeon mortality anticipated by the baseline actions considered in the previous biological opinions for the SWFSC and NWFSC. NMFS does anticipate the non-lethal take of 1 adult southern DPS Green Sturgeon per year. The actions considered in this biological opinion, when added to the baseline, would have no effect on the species' abundance, productivity, spatial structure, or diversity. As a result, we conclude that the proposed action will not appreciably reduce the likelihood of survival and recovery, by reducting the reproduction, numbers, or distribution, of the southern DPS green sturgeon.

9. Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is *not* likely to jeopardize the continued existence of Western DPS Steller sea lion, Cook Inlet DPS Beluga whale, or North Pacific Right Whale, or to destroy or adversely modify designated critical habitat for these species.

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is *not* likely to jeopardize the continued existence of blue, sei, sperm, Western North Pacific DPS and Mexico DPS humpback, fin, or bowhead whales; and the proposed action is not likely to jeopardize the continued existence of Arctic subspecies of ringed seals or Beringia DPS bearded seals. No critical habitat has been designated for these species, therefore, none will be affected.

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Puget Sound Chinook, Lower Columbia River Chinook, Upper Willamette River Chinook, Upper Columbia River Spring-run Chinook, Snake River Fall-run Chinook, Snake River Spring/summer-run Chinook, Columbia River chum, Hood Canal Summer-run chum, Lower Columbia River coho, Ozette Lake sockeye, Snake River sockeye, southern DPS green sturgeon, or to destroy or adversely modify any designated critical habitat for these species.

NMFS concurs that the proposed action is not likely to adversely affect Central North Pacific DPS and East Pacific DPS green, North Pacific Ocean DPS loggerhead, olive ridley, or leatherback turtles. NMFS concurs that the proposed action is not likely to adversely affect the following steelhead trout DPSs: Lower Columbia River DPS, Middle Columbia River DPS, Snake River Basin DPS, Upper Columbia River DPS, Upper Willamette River DPS, and Puget Sound DPS. Also, NMFS concurs that the proposed action is not likely to adversely affect western North Pacific Gray whales.

10. Incidental Take Statement

Section 9 of the ESA prohibits the take of endangered species unless there is a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Incidental take" is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity (50 CFR 402.02). Based on recent NMFS guidance, the term "harass" under the ESA means to: "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (Wieting 2016). The MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild [Level A harassment]; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering [Level B harassment] (16 U.S.C. §1362(18)(A)(i) and (ii)).

Section 9 take prohibitions do not apply to ringed or bearded seals. This incidental take statement, however, includes limits on taking of ringed and bearded seals since those numbers were analyzed in the risk analysis, and to provide guidance to the action agency on its requirement to re-initiate consultation if the take limit for any species covered by this opinion is exceeded.

Under the terms of Section 7(b)(4) and Section 7(o)(2) of the ESA, taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA, provided that such taking is in compliance with the terms and conditions of an Incidental Take Statement (ITS).

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized by Section 101(a)(5) of the MMPA. Accordingly, **the terms of this incidental take statement and the exemption from Section 9 of the ESA with respect to marine mammals become effective only upon the issuance of MMPA authorization to take the marine mammals identified here (Section 9 of the ESA, however, does not apply to ringed or bearded seals)**. Absent such authorization, this incidental take statement is inoperative.

The terms and conditions described below are nondiscretionary. PR1 and AFSC have a continuing duty to regulate the activities covered by this ITS. In order to monitor the impact of incidental take, PR1 and AFSC must monitor the progress of the action and its impact on the species as specified in the ITS (50 CFR 402.14(i)(3)). If they (1) fail to require the authorization holder to adhere to the terms and conditions of the ITS through enforceable terms that are added to the authorization, and/or (2) fail to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

10.1 Amount or Extent of Take

Section 7 regulations require NMFS to estimate the number of individuals that may be taken by proposed actions or utilize a surrogate (e.g., other species, habitat, or ecological conditions) if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (50 CFR § 402.14 (i)(1); see also 80 FR 26832 (May 11, 2015).

NMFS expects that the following marine mammal species (Table 91) may be injured or killed by entanglement in research survey gear. These individuals could be either sex and any life stage.

Table 91. Estimated injury and mortality/Level A harassment for five-year period.

Agency	**AFSC**						**IPHC**	**Total**
Area	**GOA**			**BSAI**		**CSBS**	**GOA/BSAI**	
Gear type	**Trawl**	**Longline**	**Gillnet**	**Trawl**	**Longline**	**Trawl**	**Longline**	
Steller sea lion (Western DPS)	5[2]	1[3]	1[3]	5[3]	1[3]		5[1]	**18+5[6] (23 total)**
Bearded seal				1[5]		1[5]		**2**
Ringed seal				1[5]	1[3]	1[5]	1[4]	**4**
Sperm whale (North Pacific)		1[3]					1[3]	**2**

1.Historical catch of that species during research surveys
2.Historical catch of analogous species during research surveys
3.Historical catch of that species with similar gear in a commercial fishery in the same area
4.Historical catch of that species with similar gear in a commercial fishery conducted elsewhere
5.Spatial-temporal overlap of that species' distribution with historical or planned research activities
6. 5 undetermined pinnipeds taken during research activities are conservatively estimated to be Steller sea lion, Western DPS. The unidentified pinniped taken in the Beaufort/Chukchi Sea (included in the MMPA LOA) is not included in these 5.

NMFS expects that the following fish species (Table 92) may be taken in research survey gear. These individuals could be either sex and any life stage.

Table 92. Estimated take of ESA-listed Chinook, coho, chum, and sockeye salmon in AFSC, ADFG, and IPHC surveys per year.

Species and Listing Unit	**Average Adult Escapement**	**Total Take**	**Percent of Abundance**
Non-listed Chinook	427,068	132	0.03%
Puget Sound Chinook	32,481	10	0.03%
Lower Columbia River Chinook	68,061	21	0.03%
Upper Willamette River Chinook	45,896	14	0.03%
Upper Columbia River Spring-run Chinook	9,057	3	0.03%
Snake River Fall-run Chinook	37,812	12	0.03%
Snake River Spring/summer-run Chinook	17,043	5	0.03%
Totals	**637,418**	**197**	**0.03%**
Non-listed Chum	601,231	1,691	0.3%

Species and Listing Unit	Average Adult Escapement	Total Take	Percent of Abundance
Hood Canal Summer-run Chum	27,452	77	0.3%
Columbia River Chum	11,070	31	0.3%
Totals	**639,753**	**1,799**	**0.3%**
Non-listed Coho	1,122,217	315	0.03%
Lower Columbia River Coho	56,068	16	0.03%
Totals	**1,178,285**	**331**	**0.03%**
Non-listed Sockeye	336,172	186	0.06%
Snake River Sockeye	1,373	1	0.06%
Ozette Lake Sockeye	2,321	1	0.06%
Totals	**339,866**	**188**	**0.06%**

Additionally, NMFS estimate the non-lethal take of 1 Southern DPS green sturgeon by research activities per year.

NMFS expects that the following listed species (Table 93) may be taken by acoustic noise produced by research survey gear. These individuals could be either sex and any life stage. While NMFS manages humpback whales in stocks under the MMPA, the listed entities are DPSs. The probability of encountering whales from each of the four North Pacific DPSs in various feeding areas is summarized in Wade et al (2016) and summarized in the Exposure Analysis. NMFS used these percentages to calculate the expected number of animals in the two listed DPSs that occur in the action area (Table 94).

Table 93. Summary of estimated annual take by acoustic sources over the five year period.

Species	GOARA	BSAIRA	CSBSRA	Total
Beluga whale - Cook Inlet DPS	3			3
Blue whale - Eastern North Pacific	1			1
Fin whale - Northeast Pacific	36	4		40
Humpback whale - Central North Pacific	116	45		161[1]
Humpback whale - Western North Pacific	2	4		6[1]
North Pacific right whale - Eastern North Pacific	1	1		2
Bowhead whale - Western Arctic		42		42
Sei whale - Eastern North Pacific	1	1		2
Sperm whale - North Pacific	3	19		22
Ringed seal - Arctic Subspecies/Alaska		1481	585	2066
Bearded seal - Alaska		1669	58	1727
Steller sea lion – Western DPS	281	51		217
[1]Refer to Table 94 for estimates by DPS.				

Table 94. Numbers of humpback whales expected to be part of the listed DPSs that occur in the action area that are expected to be exposed to acoustic noise from research surveys per year.

Research Area	North Pacific Distinct Population Segments listed under the ESA that occur in the action area		Total number of humpback whales exposed in each research area	Numbers of animals from each DPS		Total number of whales from listed DPSs in each research area
	WNP	Mexico		WNP	Mexico	
GOA	0.5%	10.5%	118	1	13	14
BSAI	4.4%	11.3%	49	3	6	9
CSBS	4.4%	11.3%	0	0	0	0
Total			**167**	**4**	**19**	**23**

NMFS expects that the Steller sea lion, Western DPS may be subjected to terrestrial disturbance from research activities (Table 95). These individuals could be either sex and any life stage; however, mitigation measure are included to reduce the chance of interactions with nursing mothers during breeding and pupping season. Annual and five-year estimates are presented below, and NMFS anticipates that these exposure levels will continue into the foreseeable future.

Table 95. Steller sea lion exposure to terrestrial disturbance from the physical presence of researchers in the GOARA and BSAIRA

Species	Estimated Annual exposures	Estimated exposure over 5 yr authorization period
Steller sea lion (Western DPS) in GOARA	3,082	15,410
Steller sea lion (Western DPS) in BSAIRA	112	560
Total Steller sea lion (Western DPS) All areas	3,194	15,970

10.2 Effect of the Take

Very small numbers of Steller sea lions, ringed and bearded seals, and sperm whales may be subjected to mortality and injury from entanglement in survey gear. NMFS expects that these very low numbers of take in combination with other sources of mortality outside of this action, will not affect the reproduction, survival, or recovery of these species at the population level.

Studies of marine mammals and responses to acoustic noise have shown that cetaceans and pinnipeds are likely to respond behaviorally upon hearing low and mid-frequency acoustic sounds. In addition, NMFS expects that terrestrial disturbance of Steller sea lions may elicit a behavioral response. Take is authorized, but no injuries or mortalities are anticipated or authorized associated with exposure to acoustic noise or terrestrial disturbance. Although the biological significance of those behavioral responses remains unknown, this consultation has assumed that exposure to noise sources and terrestrial disturbance might disrupt one or more behavioral patterns that are essential to an individual animal's life history. However, the behavioral responses and associated disruptions are not expected to affect the reproduction, survival, or recovery of these species.

This opinion authorizes take over a five-year period; however, NMFS expects that a similar level of anticipated take from the research activities that are part of the proposed action will occur for the forseeable future. In the Conclusion section of this opinion, NMFS determined that the level of anticipated take from research activities that will occur for the foreseeable future, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

10.3 Reasonable and Prudent Measures (RPMs)

"Reasonable and prudent measures" are nondiscretionary measures to minimize the amount or extent of incidental take (50 CFR 402.02).

The RPMs included below, along with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. NMFS concludes that the following RPMs are necessary and appropriate to minimize or to monitor the incidental take of listed cetacean and pinniped species resulting from the proposed action.

1. This ITS is valid only for the activities described in this Opinion, and for those marine mammal species for which takes have been authorized under section 101(a)(5) of the MMPA.
2. Level A take is only authorized as described in the ITS for entanglement of Steller sea lions, ringed and bearded seals, and sperm whales. The taking of other species via entanglement is prohibited and may result in the modification, suspension, or revocation of the ITS. Additionally, take of listed species may occur by Level B harassment only via acoustic noise and terrestrial disturbance. Mortality and injury from acoustic noise and/or terrestrial disturbance of any species covered in this opinion is prohibited and may result in the modification, suspension, or revocation of the ITS.
3. AFSC and PR1 shall implement a monitoring program that allows NMFS AKR to evaluate the exposure estimates contained in this Opinion and that underlie this incidental take statement.
4. AFSC and PR1 shall submit a final report to NMFS AKR that evaluates the mitigation measures and the results of the monitoring program.

10.4 Terms and Conditions

"Terms and conditions" implement the reasonable and prudent measures (50 CFR 402.14). These must be carried out for the exemption in section 7(o)(2) to apply.

In order to be exempt from the prohibitions of section 9 of the ESA, the AFSC and PR1 must comply with the following non-discretionary terms and conditions, which implement the RPMs described above and the mitigation measures set forth in this Opinion. AFSC and PR1 have a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this incidental take statement (50 CFR § 402.14(3)). If PR1 (1) fails to require the authorization holder to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added to the authorization, and/or (2) fail to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

Partial compliance with these terms and conditions may result in more take than anticipated, and may invalidate this take exemption. These terms and conditions constitute no more than a minor change to the proposed action because they are consistent with the basic design of the proposed action.

To carry out RPM #1, AFSC, NMFS PR1, or their authorization holder must undertake the following:

A. AFSC shall require their vessels engaged in research activities to possess current and valid Letters of Authorization issued by NMFS under section 101(a)(5) of the MMPA, and any take must occur in compliance with all terms, conditions, and requirements included in such authorizations.

To carry out RPM #2, AFSC, NMFS PR1, or their authorization holder must undertake the following:

A. Conduct the action as described in this document including all mitigation measures.

B. The taking of any marine mammal in a manner other than that described in this ITS must be reported immediately to NMFS AKR, Protected Resources Division at 907-586-7638 and Kristin.Mabry@noaa.gov.

C. In the event that the proposed action causes a take of a marine mammal that results in an unauthorized injury or unauthorized mortality, AFSC or IPHC should immediately cease the activity that caused the take and report the incident to NMFS AKR, Protected Resources Division at 907-586-7638 and/or by email to Kristin.Mabry@noaa.gov, and the acting NMFS Alaska Regional Stranding Coordinator at 907-271-1332 (Barbara.Mahoney@noaa.gov), and/or the acting Large Whale Entanglement Coordinator (Sadie.Wright@noaa.gov). As staffing changes occur in these acting roles, AFSC should contact Kristin.Mabry@noaa.gov in AKR PRD to obtain current contact information.

D. If the total number of actual takes that have occurred during the action approaches the allocated total number of takes specified in section 10.1 of this Incidental Take Statement, AFSC and PR1 should contact Kristin.Mabry@noaa.gov in AKR PRD to discuss continuing the operation without exceeding authorized take amounts.

To carry out RPM #3, AFSC, NMFS PR1, or their authorization holder must undertake the following:

A. Marine Mammal Visual Monitors must observe and document sightings as described in the mitigation measures. AFSC must provide actual track length and number of stations surveyed in order to calculate estimated exposures as described in the mitigation measures.

To carry out RPM #4, AFSC, NMFS PR1, or their authorization holder must undertake the following:

A. AFSC must adhere to all monitoring and reporting requirements as detailed in the LOA issued by NMFS under section 101(a)(5) of the MMPA.
B. Submit a report that summarizes listed species interactions for each field season to the Protected Resources Division, NMFS by email to kristin.mabry@noaa.gov as described in the mitigation measures and convene a post-season debrief and Q&A including AKR PRD to determine the efficacy of mitigation measures and discuss details of interactions.

11. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

In order to keep NMFS' Protected Resources Division informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats, AFSC and PR1 should notify NMFS AKR PRD of any conservation recommendations they implement in their final action.

AFSC regularly reviews procedures and investigates options for incorporating new mitigation measures and equipment into ongoing survey programs. Evaluations of new mitigation measures include assessments of the measure's effectiveness in reducing risk to protected species and their critical habitats. In addition to the mitigation measures included as part of the action, improvements to existing protected species training, observation/operating procedures, and reporting requirements will facilitate and improve the implementation of mitigation measures in the field, as follows.

1. The AFSC should initiate procedures to facilitate communication between Chief Scientists and vessel captains about protected species interactions during research surveys in order to improve decision-making regarding avoidance of adverse interactions. The intent is to draw on the collective experience of people who have been making those decisions, provide a forum to exchange information about what worked or did not work,

apply lessons learned, and improve upon future decisions regarding avoidance practices. The AFSC will coordinate among its staff and vessel captains and with those from other fisheries science centers, cooperating research partners, and other interested NMFS offices with similar experience.

2. AFSC should develop a formalized protected species training program for any crew members who may look out for marine mammals that would be required for all AFSC fisheries research projects. AFSC Chief Scientists and appropriate members of AFSC research crews should be trained using customized monitoring, data collection, and reporting protocols for protected species developed with assistance from the North Pacific Fisheries Observer Program. This would formalize and standardize the information provided to all crew that might experience protected species interactions during research activities.

3. For all AFSC fisheries research projects and vessels, instructions and protocols for avoiding adverse interactions with protected species should be reviewed and, if needed, be supplemented with information and procedures from the Observer Program training materials and any guidance on decision-making that arises from training opportunities. Informational placards and reporting procedures should be reviewed and updated as necessary for consistency and accuracy. The AFSC should incorporate specific language into its contracts and letters of acknowledgement that specify all training requirements, operating procedures, and reporting requirements for protected species that will be required for all vessels, including charter vessels and cooperating research partners.

4. NMFS recommends avoiding setting gear at night and in other weather/sea conditions when observing for marine mammals is compromised.

5. NMFS recommends using pingers on any soaking gear with vertical lines or acoustic release devices with subsurface buoys to warn approaching marine mammals.

6. AFSC should develop a monitoring and reporting program to facilitate tracking and, ultimately, mitigating vessel disturbance of pinnipeds on rookeries and haulouts.

7. Whenever space/time/budget is available, AFSC should use dedicated Protected Species Observers (observers that have no other duty besides observation) in lieu of Marine Mammal Visual Monitors on board research vessels.

8. IPHC survey vessels and any other research vessels active in Southeast Alaska should participate in the WhaleAlert program to report and view real-time sightings of whales while transiting in the waters of Southeast Alaska in summer months. More information is available at https://alaskafisheries.noaa.gov/pr/whale-alert

9. AFSC should work with PRD to develop easier recording practices for MMVM that would make their time spent monitoring more efficient.

12. Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount of incidental take is exceeded, section 7 consultation must be reinitiated immediately.

13. Data Quality Act Documentation and Pre-dissemination Review

Section 515 of the Treasury and General Government Appropriations Act of 2001 (Public Law 106-554) (Data Quality Act (DQA)) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

13.1 Utility

This document records the results of an interagency consultation. The information presented in this document is useful to NMFS and the general public. These consultations help to fulfill multiple legal obligations of the named agencies. The information is also useful and of interest to the general public as it describes the manner in which public trust resources are being managed and conserved. The information presented in these documents and used in the underlying consultations represents the best available scientific and commercial information and has been improved through interaction with the consulting agency.

This consultation will be posted on the NMFS Alaska Region website http://alaskafisheries.noaa.gov/pr/biological-opinions/. The format and name adhere to conventional standards for style.

13.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

13.3 Objectivity

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the ESA Consultation Handbook, ESA Regulations, 50 CFR Part 402.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the literature cited section. The analyses in this opinion contain more background on information sources and quality.

Referencing: All supporting materials, information, data, and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA implementation, and reviewed in accordance with Alaska Region ESA quality control and assurance processes.

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APPENDIX A. LIST OF STELLER SEA LION ROOKERIES.

This list of rookeries reflects the most accurate location information (Lewis et al 2019 NOAA Tech Memo, in press) for sites known to be currently used as rookeries, as well as sites legally designated as critical habitat rookeries, even if they haven't been observed to be used as rookeries in recent years. This comprehensive list will be used for:

- pre-survey determination of potential disturbance of Steller sea lions hauled out at rookeries by vessel transit and survey activities, and
- strategic planning of survey locations and activities as a result of those findings.

The list which includes the spatial representation of the lines depicting the spatial extent of Steller sea lion usage of these rookeries is accessible as a REST service at

https://alaskafisheries.noaa.gov/arcgis/rest/services/Steller_sea_lion_rookery_lines/MapServer

The latitude and longitude coordinates of the lines depicting the spatial extent of Steller sea lion usage of these rookeries are available in the attached draft report (Lewis et al 2019).

Contact Kristin.Mabry@noaa.gov for other methods of transmittal.