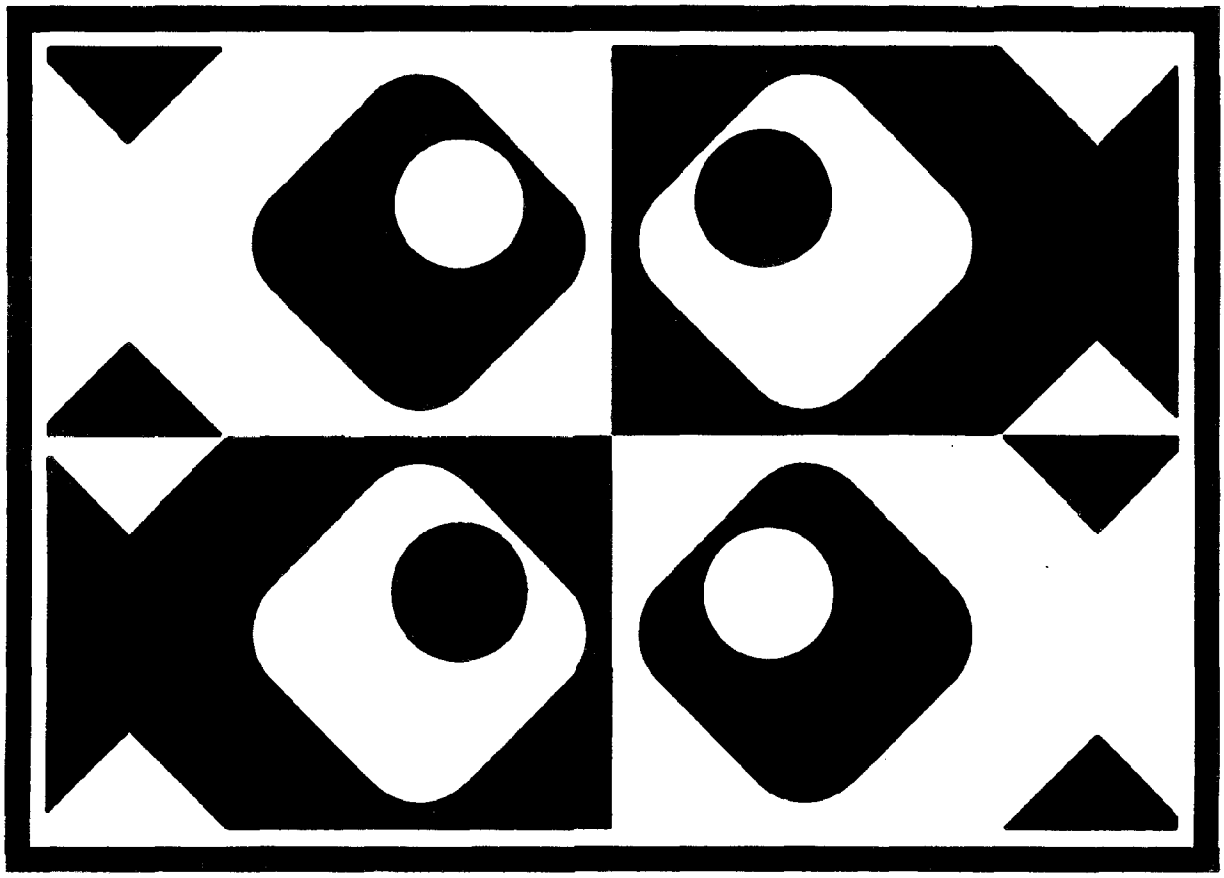
NOAA Technical Memorandum NMFS- AFSC-27

Status of Living Marine Resources off Alaska, 1993



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NOAA Technical Memorandum NMFS-AFSC-27

Status of Living Marine Resources off Alaska, 1993

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OVERVIEW

By Loh-Lee Low

Photo: AFSC

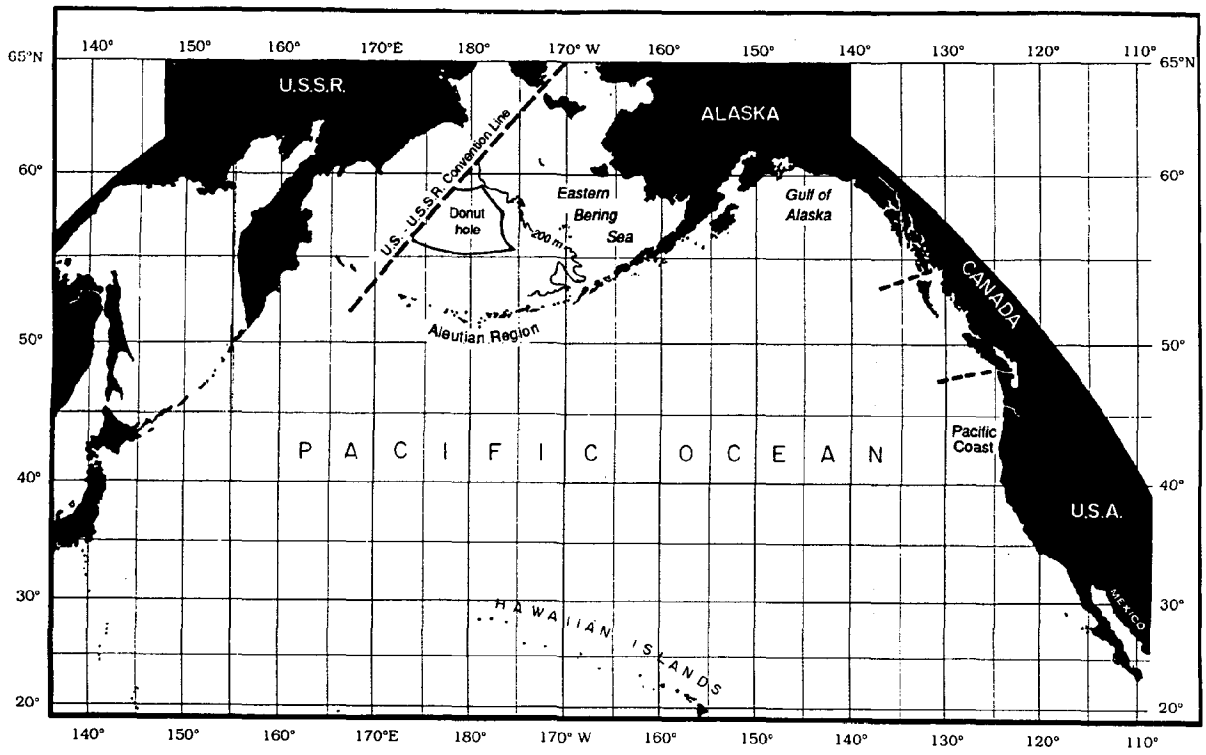
Status of Stocks off the Coast of Alaska

This report provides a species-by-species description of the status of living marine resources off Alaska as assessed for 1993. The descriptions are for resources that are primarily under the research and management jurisdiction of the National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The report was prepared by scientists from the NMFS' Alaska Fisheries Science Center, the Alaska of Fish and Game (ADF&G) and the International Pacific Halibut Commission (IPHC). It is one of a series of regional reports on the status of living marine resources throughout the United States.

The resources are grouped under six major headings: groundfish resources of the Bering Sea/ Aleutian Islands region, groundfish resources of the Gulf of Alaska, pelagic resources, shellfish, salmon, and marine mammals. There are other resources of commercial and recreational importance that are not included in this report; these are mostly inshore marine resources under the jurisdiction of the State of Alaska.

Alaska Fisheries Science Center

The Alaska Fisheries Science Center (AFSC) is responsible for research on living marine resources in Federal waters off Alaska and parts of the West Coast of the United States. This region includes the northeast Pacific Ocean and the eastern Bering Sea, which support some of the most important commercial fisheries in the world for Pacific salmon, walleye pollock, Pacific cod, sablefish, flounders, rockfishes, and crabs. The region also supports popular sport fisheries for Pacific salmon, halibut, and steelhead trout and is home to an array of marine mammal species.



The range of distribution of marine resources native to Alaska

The mission of the AFSC is to conduct research programs to generate the best scientific data for better understanding the region's resources and the environmental quality essential for their existence. The Center provides scientific data and technical advice to its constituents for better utilization and management of these living marine resources. The Center's primary constituents are the Pacific and North Pacific Fishery Management Councils, NMFS headquarters and regional offices, State and Federal agencies, international fisheries commissions, the fishing and fish processing industry, and the general public.

Groundfish Resources

The productive waters off the coast of Alaska support some of the world's largest populations of groundfish. Large-scale commercial fisheries for groundfish were developed and dominated by foreign fisheries from the early 1950s until the enactment of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977. The implementation of the MFCMA led to an extremely successful development of the domestic groundfish industry off Alaska. Under the MFCMA, joint ventures with foreign countries were first formed to involve domestic fishermen in the fisheries. Within a short 3-5 years, most of these joint ventures became purely domestic operations. Thus a thriving domestic groundfish industry was born.

Under the MFCMA, the groundfish resources became subject to management by the North Pacific Fishery Management Council (NPFMC) under two fishery management plans (FMPs): one for the Bering Sea/Aleutian Islands region and the other for the Gulf of Alaska.

The long-term potential yield (LTPY) for all groundfish resources off Alaska (Bering Sea/ Aleutian Islands region plus the Gulf of Alaska)

Fisheries Resources off Alaska

Species Group	Recent Average Yield (t) (1990-92)	Current Potential Yield (t)	Long-term Potential Yield (t)
Groundfish (BSAI)	1,664,710	2,422,495	2,909,500
Groundfish (GOA)	222,760	734,550	451,070
Pacific Halibut (U.S.)	31,000	29,000	30,000
Pacific Herring	45,860	45,100	Unknown
Shellfish	125,220	125,220	95,370
Salmon	320,500	282,200	282,200
Total	2,410,050	3,638,565	3,813,240

totals more than 3.39 million metric tons (t). The current potential yield (CPY) of 3.19 million t is close to LTPY, reflecting excellent condition of the stocks. For the Bering Sea/Aleutian Islands region, the average groundfish catch in recent years (1990-92) was about 1.66 million t; the 1992 catch of 1.76 million t had an ex-vessel value above $522 million. For the Gulf of Alaska, the average 1990-92 catch was 222,800 t; the 1992 catch of 213,000 t had an ex-vessel value of $133 million.

For the Bering Sea/Aleutian Islands region, the major species groups harvested are walleye pollock (77%), Pacific cod (10%), flatfishes (9%), Atka mackerel (1.8%), rockfishes (0.9%), and sablefish (0.2%). Except for Greenland turbot, all the groundfish species are high in abundance and in excellent condition. The LTPY or maximum sustainable yield (MSY) for the complex is about 2.91 million t. The CPY of 2.42 million t is 17% below LTPY, which mostly reflects lower abundance of walleye pollock in recent years.

The major species groups harvested in the Gulf of Alaska are walleye pollock (37%), Pacific cod (34%), sablefish (10%), flatfishes (9%), and slope rockfish (8%). Overall abundance of groundfish in the Gulf of Alaska has been relatively stable. The most abundant species in the Gulf are flatfishes, particularly arrowtooth flounder, followed by pollock and Pacific cod. The abundances of flatfishes and Pacific cod are high. Pollock and sablefish abundances are at average levels. The abundances of all rockfishes are generally low. The LTPY for Gulf of Alaska groundfish is 451,000 t. The CPY is 735,000 t, well above LTPY because flatfishes are particularly abundant. The RAY was 222,700 t, indicating that the Gulf of Alaska groundfish resources are still substantially underutilized.

In addition to the general groundfish complexes, Pacific halibut is a groundfish species that has supported an important traditional fishery for the United States and Canada. The resource is fully utilized and managed by IPHC. The LTPY for the entire Pacific halibut resource totals 30,000 to 36,000 t; the portion in U.S. waters is about 30,000 t. The CPY in U.S. waters is 29,000 t, reflecting the generally good condition of the resource. Recent average catches (1990-92) were 31,000 t in U.S. waters and, including Canada, were 35,700 t.

Pelagic Resources

In the Gulf of Alaska, major concentrations of Pacific herring occur in Southeast Alaska, Prince William Sound, and Kodiak Island-Cook Inlet. In the Bering Sea, they occur in Northern Bristol Bay and Norton Sound. In the Chukchi Sea and Arctic

Bering Sea-Aleutian Islands Groundfish Resources

Species	Recent Average Yield (t) (1990-92)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Pollock	1,281,000	1,398,700	1,944,600	Full
Pacific cod	170,300	164,500	143,000	Full
Yellowfin sole	90,400	238,000	220,000	Full
Greenland turbot	5,800	7,000	27,100	Full
Arrowtooth flounder	5,600	72,000	59,000	Under
Rock sole	29,900	185,000	160,200	Under
Other flatfish	12,100	191,000	148,500	Under
Sablefish	3,270	4,100	10,900	Full
Pacific ocean perch	14,500	17,170	14,900	Full
Other rockfish	930	1,325	1,300	Full
Atka mackerel	30,260	117,100	117,100	Full
All Others	20,650	26,600	62,900	Under
TOTAL	1,664,710	2,422,495	2,909,500	

Gulf of Alaska Groundfish Resources

Species	Recent Average Yield (t) (1990-92)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Pollock	81,400	160,000	169,000	Under
Pacific cod	76,680	56,700	56,700	Full
Sablefish	21,600	20,800	23,500	Full
Slope rockfish	17,470	21,580	21,580	Full
Flatfish	21,160	466,750	169,000	Under
Thornyhead rockfish	1,500	1,180	3,750	Unknown
Pelagic shelf rockfish	2,480	6,740	6,740	Full
Demersal shelf rockfish	470	800	800	Full
TOTAL	222,760	734,550	451,070	

Ocean, abundance is low and commercial concentrations of Pacific herring have only been located in Kotzebue Sound. The fishery takes place in inshore areas.

The LTPY for Pacific herring off Alaska is not known because stock abundance is highly variable. The CPY is about 45,100 t. The 1992 total Pacific herring harvest of 56,400 t (23,850 t in the Gulf of Alaska and 32,550 t in the Bering Sea) had an ex-vessel revenue of $30 million. The majority of the harvest was roe herring and the remainder was food and bait herring and roe-on-kelp.

In the Gulf of Alaska, stocks are at moderate to high abundance levels and the outlook is for increases as a strong 1988 year class recruits to the fisheries. In the Bering Sea, Pacific herring stocks declined through the 1980s as the very strong 1977-78 year classes which sustained the fisheries aged and declined in abundance. In 1992, a strong 1988 year class recruited into the fishery and those fish should further increase abundance of the stocks in 1993.

Shellfish Resources

The king and Tanner crab fisheries are currently the most important shellfish fisheries off Alaska. Three species of king crab (red, blue, brown or golden) and two species of Tanner crab (*Chionoecetes bairdi and C. opilio*) are harvested commercially. Historically, red king crab has predominated in king crab landings. In recent years, blue and brown king crab have become relatively more important.

During the developmental phase of the Tanner crab fishery, *C. bairdi* dominate the landings. In more recent years, there has been a shift in species composition; the *C. opilio* catch is currently 10-times the *C. bairdi* catch.

The annual ex-vessel value of Alaskan king and Tanner crab fisheries averaged $195 million during the 1978-90 period. The 1992 value was $287 million; 25% ($70 million) was attributable to king crab and the rest to Tanner crab. The Bering Sea crab stocks are jointly managed by the State of Alaska and the Federal government under an FMP of the NPFMC. Gulf of Alaska crab and shrimp resources are managed by the State of Alaska.

The U.S. fishery for shrimp in Alaskan waters is currently at a low level. The western Gulf of Alaska has been the main area of operation. From the 1960s, catches rose steadily to about 58,000 t in 1976, and declined precipitously after that time. During the 1960-90 period, the ex-vessel value of western Alaska shrimp fisheries averaged $4 million annually, with a peak value of $14 million in 1977. Since 1988, shrimp catches have been minor. The 1992 catch in the Gulf of Alaska was about 900 t, worth about $680,000. Shrimp catches used to be fairly large in the Bering Sea in the early 1960s (32,000 t in 1963). The fishery ceased operation in 1973 after the resource was depleted by foreign fisheries.

The sea snail stocks are located primarily in the eastern Bering Sea shelf. The stock is underutilized because the fishery for sea snails is undeveloped. The status of the snail stocks is not clear, although resources are known to be generally abundant.

Besides the major shellfish resources summarized above, fishermen also harvest the following shellfish resources mostly within State waters: Dungeness crab, Korean horse hair crab, sea cucumber, sea urchin, scallop, abalone, geoduck, and octopus. The combined value of these catches in 1992 (4,340 t) was $13 million.

Salmon Resources

There are five species of Pacific salmon: chum, pink, sockeye, coho, and chinook salmon. Pacific salmon are anadromous; they spawn in fresh water, migrate and rear in the open ocean, and return to their home stream or lake to repeat the life cycle.

The Pacific salmon fishery in Alaska contributes significantly to the food supply and economy of the Nation and ranks as the largest non-government employer in Alaska with sales exceeding those of tourism, mining, or forest products. The fishery provides adundant recreational opportunities and is an integral part of Alaska native culture and heritage. Recent catches (1990-92) exceed 155 million

Pacific Herring Resource

Species	Recent Average Yield (t) (1990-92)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Bering Sea-Aleutians	23,230	28,200	Unknown	Full
Gulf of Alaska	22,630	16,900	Unknown	Full
Total	45,860	45,100	Unknown	Full

Pacific Halibut Resource

Species	Recent Average Yield (t) (1990-92)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Bering Sea-Aleutians	3,600	2,800	---	Full
Gulf of Alaska	27,200	25,900	---	Full
Pacific Coast	200	300	---	Full
Off Canada	4,700	4,500	---	Full
Total	35,700	33,500*	30,000-36,000	Full
U.S. Total	31,000	29,000		

* Higher by 16,000 t if sports catch, bycatch, and waste are included.

Alaska Shellfish Resources

Species	Recent Average Yield (t) (1989-91)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
King crabs	12,710	12,710	27,070	Full
Tanner crabs	112,510	112,510	40,900	Full
Shrimp	0	300	22,600	Full
Sea snails	0	1,800	4,800	Under
Total	125,220	125,220	95,370	

Alaska Salmon Resources

Species	Recent Average Yield (t) (1990-92)	Current Potential Yield (t) (1980-92)	Long-term Potential Yield (t)	Status of Utilization
Pink	127,300	113,200	113,200	Full
Sockeye	138,900	109,000	109,000	Full
Chum	31,700	38,200	38,200	Full
Coho	17,800	16,100	16,100	Full
Chinook	4,800	5,700	5,700	Full
Total	320,500	282,200	282,200	Full

fish or 320,500 t. Ex-vessel value of the 1992 catch was about $575 million.

Management of Pacific salmon in Alaska's vast marine area with a coastline of nearly 34,000 miles is accomplished by Federal and State agencies in a complex mixture of domestic and international bodies, treaties, regulations and agreements. The State of Alaska has prime responsibility for managing the Pacific salmon resource, where most of the fishery takes place inshore. Management in the U.S.

Exclusive Economic Zone (EEZ) is the responsibility of NMFS and the NPFMC.

Recreational fishing is permitted in all regions of the EEZ off Alaska under ADF&G regulations. The recreational catch in the EEZ is probably less than several hundred salmon with most taken in the charter boat fishery. The statewide sport catch within State waters in 1990 was about 909,000 fish.

The five species of Pacific salmon are fully utilized. The stocks have generally rebuilt to or are beyond previous high levels. On a regional basis, some stocks may be overutilized because of mixed stocks in the catch.

Marine Mammal Resources

Forty-two species of marine mammals in U.S. waters of the North Pacific Ocean are under the jurisdiction of the U.S. Department of Commerce. These include 31 species of whales, dolphins and porpoises, and 11 species of seals and sea lions. Six species are found only in Alaska.

Fourteen of the most commonly observed species of marine mammals are normally found close to shore. The other species usually remain in offshore waters, on remote islands, or are rare in number and seldom seen. Most marine mammals make long-distance migrations or move thousands of miles within smaller areas of the ocean between seasons of the year. These movements occur when marine mammals, especially whales and dolphins, travel from one feeding ground to another or spend the breeding season in lower latitudes and the major feeding and calf-rearing seasons in higher latitudes.

There are several populations of marine mammals that only spend a portion of the year in Alaska, such as humpback whales and northern fur seals, whereas others are found year-round inAlaska, such as the bowhead whale. These zoogeographic differences have lead to unique life history strategies and result in the need to manage accordingly. Management of marine mammals is carried out under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973.

Status of Resident and Selected Species of Marine Mammals off Alaska[1]

Species	Abundance	Trends (% Change)
Bowhead whale	7,500	+3.1/yr (1978-88)
Gray whale	20,869 (19,737-22,489)	+3.3%/yr (1968-88)
Humpback whales	>2,000	Unknown
Killer whale	>300	Unknown
Beluga	15,800-18,450	Unknown
Dall's porpoise	300,000-600,000	Unknown
Harbor porpoise	Unknown	Unknown
Northern sea lion	>34,844	-70%
Northern fur seal	982,000	-50% (1975-90)
Harbor seal	Uncertain (<100,000)	-60% (1976-92)
Spotted[2] seal	Unknown	Unknown

[1] Bowhead, gray, and humpback whale estimates are for the entire eastern North Pacific Ocean; all others are for Alaska.
[2] Other ice-associated seals are the bearded, ribbon, and ringed seals.

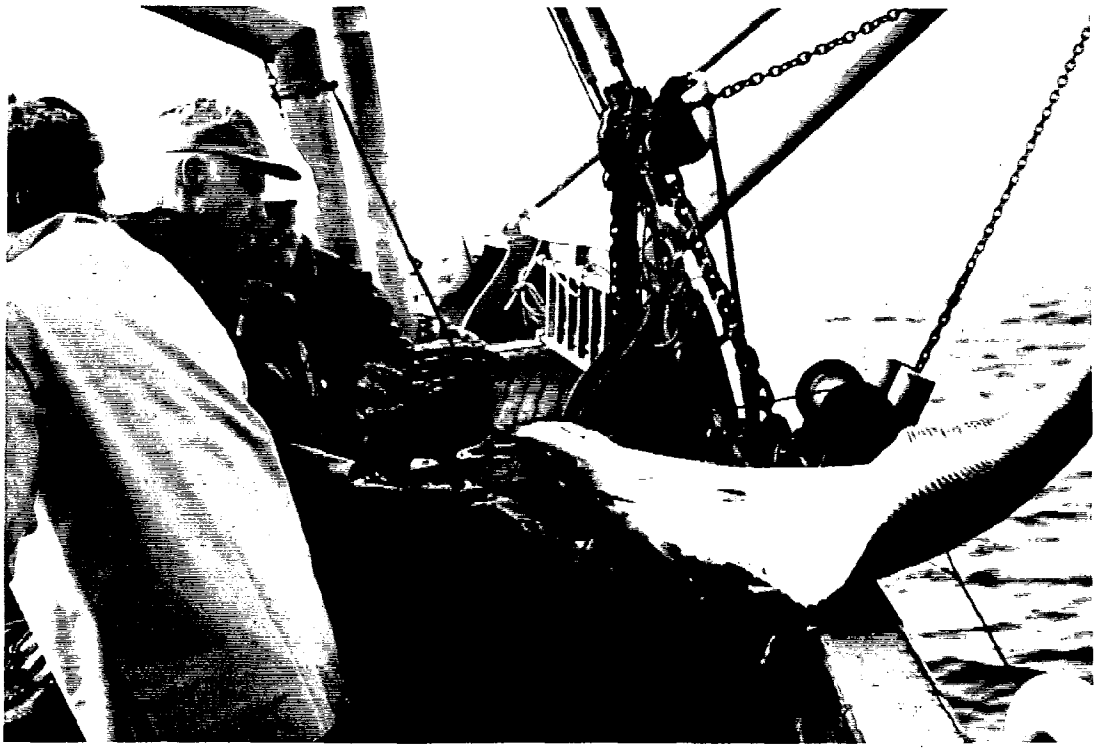


Photo: IPHC

Glossary of Common Abbreviations and Terms

MFCMA -- Magnuson Fishery Conservation and Management Act of 1976.
ESA -- Endangered Species Act.
MMPA -- Marine Mammal Protection Act.
NMFS -- National Marine Fisheries Service.
NOAA -- National Oceanic and Atmospheric Administration.
AFSC -- Alaska Fisheries Science Center
NWFC -- Northwest Fisheries Science Center
SWFC -- Southwest Fisheries Science Center
ADFG -- Alaska Department of Fish and Game
NPFMC -- North Pacific Fishery Management Council
PFMC -- Pacific Fishery Management Council
INPFC -- International North Pacific Fisheries Commission.
CalCOFI -- California Cooperative Oceanic Fisheries Investigations.
IPHC -- International Pacific Halibut Commission

ABC -- Acceptable biological catch. A catch level that can be justified on biological and ecological grounds without reference to social or economic factors. Scientists use various mathematical methods to estimate ABC, depending on the stock type and available data. Similar to current potential yield (CPY).

LTPY -- Long-term potential yield: The maximum long-term average yield (catch) from the resource. It is similar to maximum sustainable yield (MSY).

CPY -- Current potential yield: The current catch that may be obtained from the resource. It is similar to acceptable biological catch (ABC) which measures the biological production potential of the stock.

RAY -- Recent average yield: This is current average catch, denoted usually by a specific time period.

TAC -- Total allowable catch: Total allowable catch is the total regulated catch from a stock in a given time period, usually a year.

Mortality rates: The rate at which fish die from natural causes or through fishing. Mortality rates can be described in several ways. The easiest--total annual mortality rate--defines the fraction of the fish within a group that die during the year. These rates are difficult to use mathematically when describing the relative contribution of different types of natural or fishing mortality to the total mortality of fish during a year. Thus, instantaneous mortality is used.

Instantaneous mortality rate: An instantaneous mortality rate is the fraction of the population of fish that dies in a very short (instantaneous) period of time. There is a relatively simple mathematical conversion between instantaneous rates and annual rates. For example, the total instantaneous mortality rate, often denoted by Z, is equivalent to the annual rate A, according to the formula: $A = 1 - e^{-z}$.

M -- Natural mortality is the mortality due to natural causes.

F -- Fishing mortality is the mortality due to fishing.

Z -- Total mortality rate is the combined effect of all sources of mortality acting on a fish population. Thus $Z = M + F$.

Reference fishing mortality rates: There are specific rates of F that measure how close a stock is to full exploitation. They are defined in terms of an increase in yield from a year class over its lifespan as fishing mortality increases. When no fish are taken, there is no yield from the year class. As fishing increases, the yield increases, but at a decreasing rate.

F_{max} is the point at which the increased yield for additional effort is zero; that is, additional fishing mortality will not increase yield, but in fact, may decrease it as fish are caught before they are fully grown.

F_{msy} is the rate of fishing mortality when maximum sustainable yield for the stock is achieved.

$F_{0.1}$ is a point at which the increase in yield for increased effort is 10% of what it was when fishing mortality was very low.

$F_{35\%}$ is the fishing mortality rate that reduces spawning biomass per recruit ratio to 35% of the unfished level. This rate has often been adopted by the PFMC and NPFMC as the fishing rate to calculate ABC. The $F_{30\%}$ has often been adopted as the $F_{overfishing}$ rate.

CPUE -- Catch per unit effort: This is an index of stock abundance.

Recruitment: The amount of fish, in numbers or weight, that reach a certain size or age in a specific year. For example, all fish reaching their second year would be age-2 recruits. This is often used to describe the strength of a year class.

Year class (or cohort): Fish of the same stock born in the same year. Occasionally a stock produces a very small or very large year class and this group of fish is followed closely by assessment scientists since it can be pivotal in determining the stock abundance in successive years.

Population: An interbreeding group of living marine organisms, such as a species in a geographic area.

Stock: A portion of the population that is reasonably well mixed and is geographically distinct in terms of fishery and management.

1. WALLEYE POLLOCK

By Vidar G. Wespestad

Photo: AFSC

The walleye pollock (*Theragra chalcogramma*) is the most abundant groundfish species in the eastern Bering Sea/Aleutian Islands region, comprising well over 50% of the total groundfish catch. Total ex-vessel value of the 1.2 million t catch in 1991 was $232 million. Walleye pollock is a semidemersal species that is primarily pelagic during the first few years of life and then becomes increasingly demersal in behavior as it ages.

The species is found in greatest abundance along the outer continental shelf and slope between the 100 and 500 m depth contours. Pollock migrate from deep to shallow water in summer and return to deep water in autumn. They are both bottom and pelagic feeders and consume plankton, krill, and fish. The walleye pollock is highly cannibalistic, with its young a major component of its diet. They also occur pelagically in deep waters of the Aleutian Basin. Stock structure of pollock has not been well delineated. For the purpose of management within the U.S. EEZ, the resource is divided into two major regions: the eastern Bering Sea and the Aleutian Islands region.

Bering Sea pollock recruit to the fishery at age 3-4 years, which corresponds to their age of maturity, at an average size of 35-40 cm and 0.25-0.40 kg. The rate of natural mortality of exploited pollock is 0.3 and they survive in significant numbers to age 9. Strong year classes persist to about age 16-18 years in the commercial catch. The maximum observed age for pollock is 31 years. Maximum length is 91 cm and maximum weight is 5 kg.

From 1954 to 1963, pollock were harvested at low levels in the eastern Bering Sea. Directed fisheries began in 1964. Catches increased rapidly during the late 1960s and reached a peak of 1.9 million t in 1972. Since 1977, catch quotas have ranged from 950,000 to 1.3 million t. Catches in the Aleutian Islands region have always been less than those in the eastern Bering Sea. Catches in this area increased from 1980 to 1984 due to increased foreign effort and have decreased in recent years as the foreign fishery was phased out and domestic fisheries began to exploit the resource.

WALLEYE POLLOCK

Eastern Bering Sea, Aleutian Islands and Aleutian Basin
COMMERCIAL CATCH (1,000 t)

	Eastern Bering Sea			Aleutian Islands				Aleutian Basin
Year	Foreign	JVP	DAP	Foreign	JVP	DAP	Total	
1977	978	0	0	8	0	0	986	0
1978	979	0	0	6	0	0	985	0
1979	914	0	0	10	0	0	924	0
1980	948	11	0	58	0	0	1,017	15
1981	931	42	0	56	0	0	1,029	1
1982	903	53	0	56	2	0	1,014	4
1983	835	145	1	56	3	0	1,040	71
1984	862	230	6	70	7	4	1,179	181
1985	771	370	38	51	7	1	1,238	336
1986	337	805	47	15	30	1	1,235	1,061
1987	4	1,015	218	0	28	1	1,266	1,325
1988	0	739	489	0	41	2	1,271	1,396
1989	0	227	952	0	5	11	1,195	1,399
1990	0	22	1,180	0	0	79	1,259	917
1991	0	0	1,038	0	0	79	1,117	297
1992	0	0	1,348	0	0	50	1,398	3

JVP: Joint Venture Processing DAP: Domestic Annual Processing

Two important developments occurred in the Bering Sea pollock fishery in the 1980s. The first was the initiation of high-seas pollock fisheries in the central Bering Sea (the "donut hole" area) outside of the U.S. and Soviet EEZs. The second was the development of a U.S. fishery on spawning pollock in the vicinity of Bogoslof Island (Bering Sea Area 518). In 1984, the donut hole catch was only 181,000 t. The catch grew to a peak of 1.4 million t in 1989; this exceeded the pollock catch within the U.S. Bering Sea EEZ. The catch fell rapidly to 917,000 t in 1991 and 297,000 t in 1992. The donut hole fishery ended in 1993 under terms of a temporary (1993-94) multilateral moratorium. The Bogoslof fishery occurs in deep water off the eastern Bering Sea shelf. In 1987 the catch was 377,000 t. It decreased by 36,100 t in 1989, but increased to 264,800 t in 1991. In 1992, fishing in the Bogoslof Island area was prohibited in response to the rapid decline of Aleutian Basin pollock abundance; biological information suggests that fisheries in the Aleutian Basin and the Bogoslof Island area are harvesting the same group of fish.

Assessment of eastern Bering Sea pollock utilizes information from age-structured models, bottom trawl surveys, and hydroacoustic surveys. Bottom trawl surveys have been conducted annually since 1977 and hydroacoustic surveys have been repeated trienally since 1979. Three age-structured population dynamics models have been employed to assess pollock: cohort analysis, a catch-at-age model (CAGEAN), and a stock synthesis model. All three models show the same biomass trend; however, the cohort model results are reported below to indicate biomass levels.

The abundance of pollock in the eastern Bering Sea has risen from a low of 4.0 million t in the late 1970s (induced by large removals in the early to mid-1970s and by reduced recruitment) to a peak of 15.8 million t in 1985. Most of the increase during the early 1980s was due to the recruitment of a very strong 1978 year class. The population has since been declining following lower levels of recruitment in the early 1980s and aging of the 1978 year class. A strong 1989 year class began recruiting into the fishery in 1992. This year class is expected to

WALLEYE POLLOCK
Eastern Bering Sea and Aleutian Islands

	Eastern Bering Sea	Aleutian Islands
Average catch (1977-92)	1.1 million t	39,071 t
Long-term potential yield (MSY)	1.8 million t	144,600 t
Acceptable biological catch (1993)	1.34 million t	58,672 t
Fishing strategy	$F_{35\%}$	$F_{35\%}$
Age of recruitment	3 years	
Size at recruitment	35 cm, 251 g	
Maximum age	31 years	
Abundance and trend	Moderate-stable	Unknown
Recreational importance	None	None
Subsistence use	Minor	Minor
Management	BSAI Groundfish FMP	
Assessment Method	Age structured	Trawl survey
Status of exploitation	Fully exploited	Fully exploited
M	0.30	0.20
F_{MSY}	0.38	
$F_{(35\%,\ 1993)}$	0.37	0.42

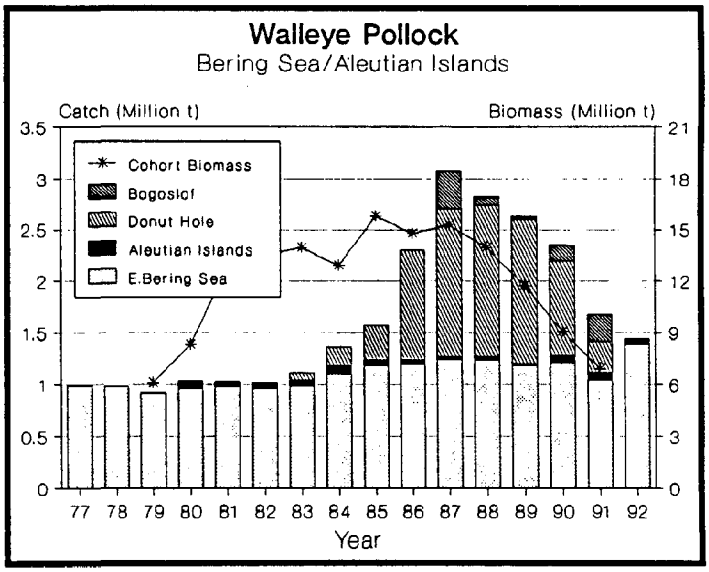
contribute significantly to the fishery for the next few years and end the declining trend. Trawl surveys also indicate that the 1990 and 1991 year classes may be above average. If these year classes hold up, then eastern Bering Sea pollock biomass is expected to continue increase through the mid-1990s. The ABC for the eastern Bering Sea stock was estimated to be 1.34 million t from a biomass of 5.9 million t in 1993.

Sufficient data are not available to perform an age-structured analysis for the Aleutian Islands stock; thus the biomass is estimated from occassional trawl surveys. The 1993 exploitable biomass is estimated to be 195,600 t, with an ABC of 58,700 t.

For the Bogoslof Island area, occasional hydroacoustic surveys were conducted during February-March to estimate the spawning biomass. The biomass was estimated to be 2.4 million t in 1988, 2.1 million t in 1989, 0.6 million t in 1991, and 0.8 million t in 1992. The ABC was estimated to be 169,000 t in 1993.

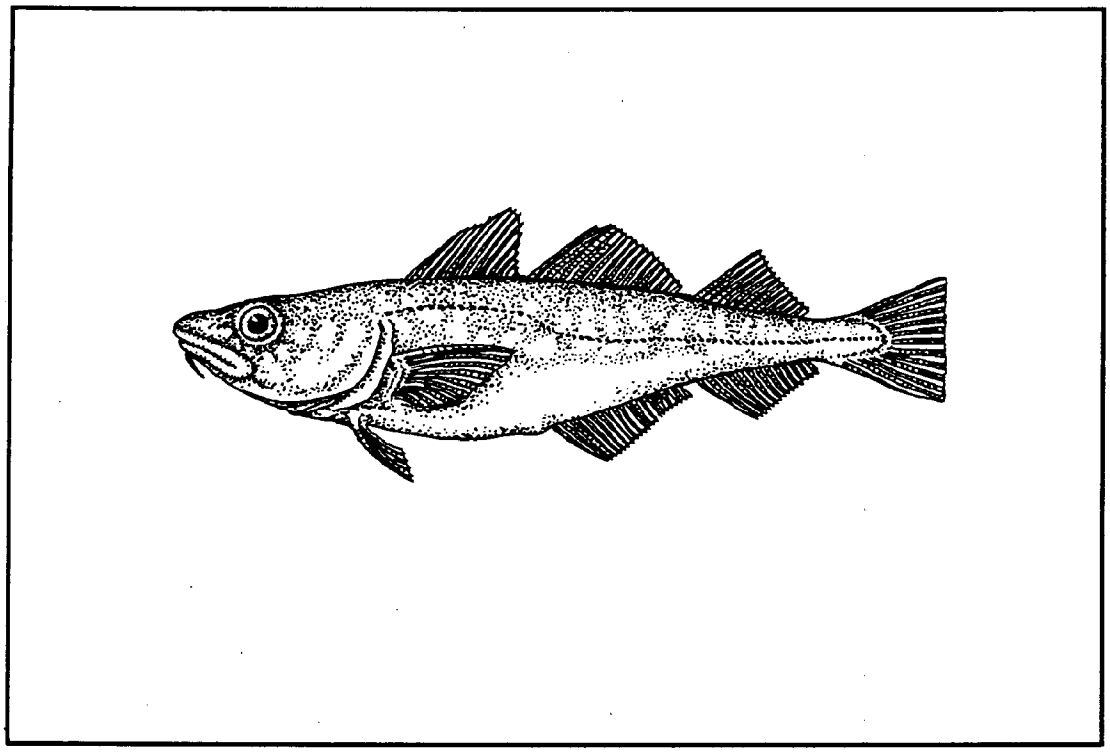
For further information

Wespestad, V. G., and P. Dawson. 1992. Walleye pollock. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.



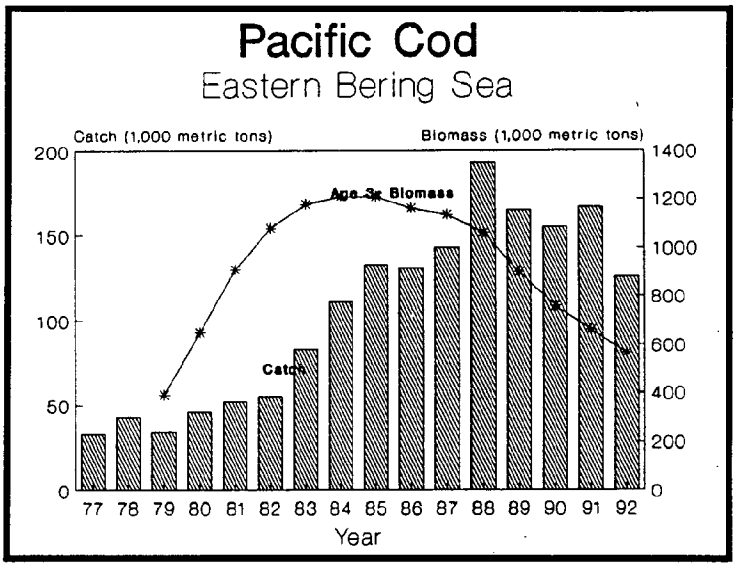
2. PACIFIC COD

By Grant G. Thompson



In North American waters, Pacific cod (*Gadus macrocephalus*) are distributed from Santa Monica Bay, California, through the Gulf of Alaska, Aleutian Islands, and eastern Bering Sea to Norton Sound. They occur demersally on the continental shelf and upper continental slope. They are omnivorous feeders that attain sizes in excess of 100 cm in length and 20 kg in weight. Ages up to 18 years have been observed, although young fish (ages 3 to 8) comprise the bulk of the catch. Spawning occurs between January and April, perhaps peaking in March. Pacific cod is harvested using a variety of gear types, including (in order of catch volumes) trawl, longline, and pot gear. Fishing has historically occurred year-round.

Tagging studies have demonstrated significant migration of Pacific cod between the Bering Sea and the Aleutian Islands region. Therefore, the resource is managed as a single unit under the NPFMC's



FMP for groundfish of the Bering Sea and Aleutian Islands region. Although foreign and joint venture fleets were major participants in the fishery throughout most of the 1980s, growth in the domestic fleet has altered this picture dramatically. The foreign fleet has not received an allocation since 1987, and the joint venture fleet has not received an allocation since 1990. Pacific cod catches have increased substantially from the average level of 41,000 t observed from 1977 to 1979. Total landings peaked in 1988 when 198,000 t were taken in the eastern Bering Sea and Aleutian Islands region. Total landings in 1991 were the second highest on record, with 176,000 t reported for the two areas. Without exception, the vast majority of the combined-area catches are taken in the eastern Bering Sea.

PACIFIC COD
Eastern Bering Sea and Aleutian Islands

Average catch (1977-92)	= 115,000 t
Long-term potential yield	= 143,000 t
Acceptable biological catch (1993)	= 164,500 t
Age/length at recruitment	= 3 yrs/42 cm
Age/length at 50% maturity	= 5.3 yrs/61 cm
Maximum observed age	= 18 yrs
Abundance and trend	= Average, declining
Stock biomass (age 3+, model projection)	= 690,000 t
Harvest strategy	= $F_{35\%}$
Importance of recreational fishery	= Negligible
Management	= BSAI Groundfish FMP
Status of exploitation	= Fully exploited
Projected spawning stock per recruit	= Above maintenance level
Assessment Method	= Age structured

$F_{0.1}$ = 0.142 $F_{35\%} = F_{overfishing}$ = 0.139 F_{Max} = 0.427 $F_{30\%}$ = 0.121
$F_{1981-92\ average}$ = 0.11 F_{1992} = 0.148 M = 0.29

Currently, the stock is declining following a period of high abundance that was fueled by an exceptionally strong year class spawned in 1977. Good (though not exceptional) year classes were spawned in 1978 and 1982, helping to sustain a high biomass level. Throughout the 1980s, trawl survey estimates of biomass for the eastern Bering Sea portion of the stock exceeded 900,000 t, peaking in 1987 at 1,142,000 t. Model estimates of biomass for this area and period show a similar abundance trend. However, back-to-back poor year classes from 1986 and 1987 have led to a pronounced decline from the high biomass levels observed during most of the

PACIFIC COD
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (1,000 t)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Eastern Bering Sea										
Foreign	39	57	56	40	54	0	0	0	0	0
Joint Venture	10	24	36	58	47	107	44	8	0	0
Domestic	34	29	41	33	42	86	120	155	167	126
Subtotal	83	111	133	131	143	193	165	163	167	126
Aleutian Islands										
Foreign	2	1	1	0	0	0	0	0	0	0
Joint Venture	5	6	6	6	10	3	0	0	0	0
Domestic	3	14	6	4	3	2	4	8	8	38
Subtotal	10	22	13	10	13	5	4	8	8	38
Total	93	133	145	141	157	198	169	171	176	164

1980s. The trawl survey biomass estimates for the eastern Bering Sea portion of the stock in 1990, 1991, and 1992 were only 709,000 t, 533,000 t, and 547,000 t, respectively, with model estimates of biomass coming in only slightly higher. Although the stock is declining, this is more likely due to unusually low recruitment than to excessive fishing. The MSY for Pacific cod cannot be accurately estimated; however, historical data suggest the LTPY to be 143,000 t.

For further information

Thompson, G. G. 1992. Pacific cod. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1993, p. 2:1-2:37. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

Thompson, G. G., and R. G. Bakkala. 1990. Assessment of the eastern Bering Sea Pacific cod stock using a catch-at-age model and trawl survey data. Int. North Pac. Fish. Comm. Bull. 50:215-236.

3. YELLOWFIN SOLE

By Thomas K. Wilderbuer

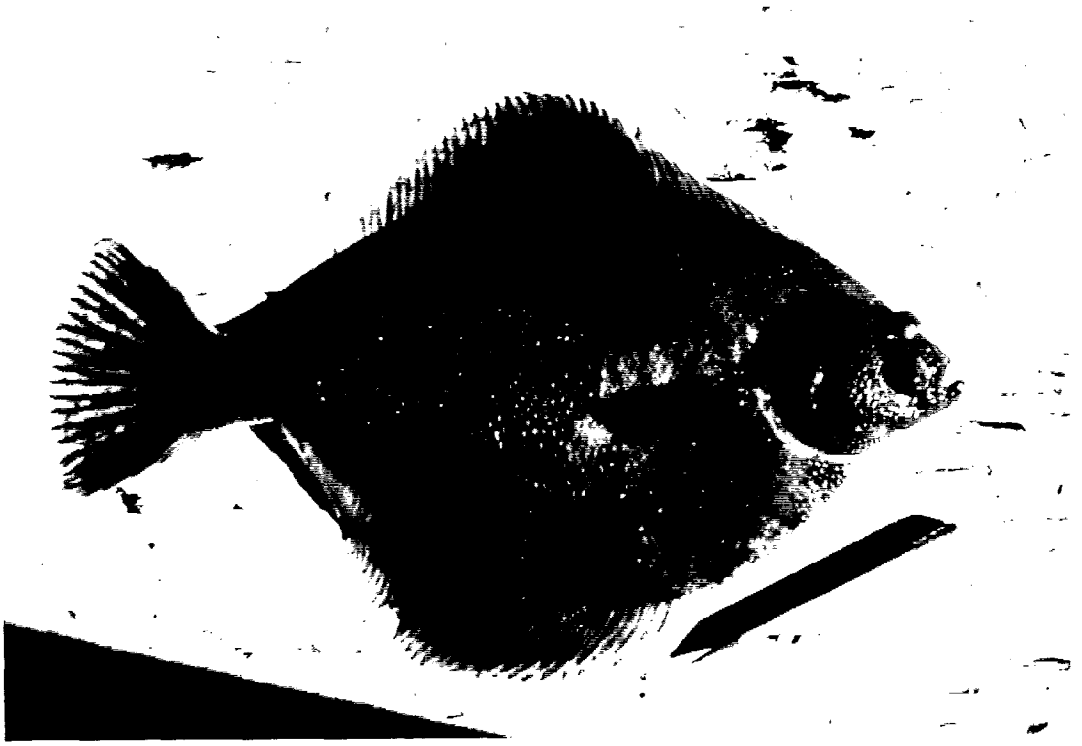
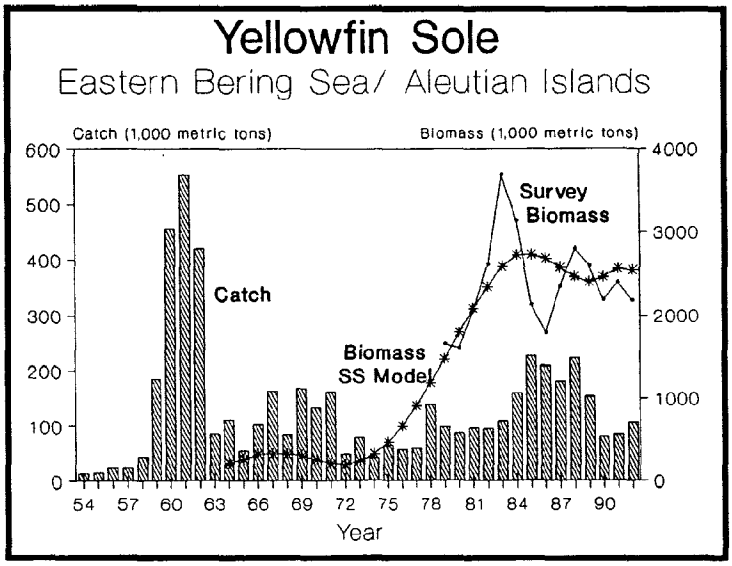


Photo: AFSC

Yellowfin sole (*Pleuronectes asper*) inhabits continental shelf waters of the North Pacific Ocean from off British Columbia, Canada, to the Chukchi Sea. It is the most abundant flatfish in the North Pacific Ocean and by far the most abundant in the eastern Bering Sea--the only region in North America where it forms commercially harvestable concentrations.

Yellowfin sole is a small flatfish attaining a maximum size of about 40 cm and 700 g; it averages about 26 cm and 200 g in commercial catches. In summer, yellowfin sole are found from nearshore areas to depths of about 100 m. In winter, concentrations of adults move to depths between 50 and 200 m to avoid ice cover. Spawning occurs from June to August in nearshore waters. Young juveniles develop in these nearshore waters and gradually shift to deeper water and, at lengths of 16 to 20 cm (mainly ages 5-8 years), they begin occupying much the same waters as the larger fish.



YELLOWFIN SOLE
Eastern Bering Sea
COMMERCIAL CATCH (1,000 t)

Category	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Domestic	0	0	0	0	0	9.8	1.7	10.9	84.5	106.0
Joint-venture	22.5	32.8	126.4	151.4	179.6	213.3	151.5	69.7	0	0
Foreign										
Japan	64.8	83.9	59.5	49.3	1.1	0	0	0	0	0
U.S.S.R.	0	8.0	8.2	0	0	0	0	0	0	0
ROK	21.0	34.9	33.0	7.6	0.7	0	0	0	0	0
Others	0	0	0	0.2	0	0	0	0	0	0
Total	108.4	159.5	227.1	208.6	181.4	223.2	153.2	80.6	84.5	106.0

Eastern Bering Sea yellowfin sole are from a single stock. Their distribution extends into the Aleutian Islands region but only to a limited extent and in minor abundances.

Fisheries for yellowfin sole were initiated by Japan in 1954. Japanese and other foreign fisheries continued to take yellowfin sole until 1987, after which all of the catch was allocated to U.S. fisheries. The species was intensively exploited for fish meal during the early years of the fisheries, with catches ranging as high as 553,700 t (in 1961) and averaging 404,000 t in 1959-62. Catches of this magnitude were more than the stock could sustain and subsequently they caused a sharp decline in abundance. Following a recovery of stock abundance during the 1970s, catches have ranged as high as 227,100 t (in 1985) and averaged 131,793 t from 1977 to 1992. Catches declined to 106,000 t in 1992 mainly as a result of limitations on bycatch of prohibited species rather than to a decline in abundance. Yellowfin sole has been mainly utilized for human consumption since the early 1960s.

Cohort analysis and stock synthesis modeling indicate that stock abundance during the 1980s was as high, if not higher, than abundance during the early years of the fishery. Surveys have shown unreasonable biomass fluctuations in the 1980s ranging from 1.8 to 3.9 million t. Nevertheless, even the lower estimates demonstrate that the abundance of yellowfin sole remains high. The 1992 survey estimate was 2.2 million t. Results from stock synthesis indicate that biomass was as high as 2.8 million t in 1984 and is estimated at 2.6 million t in 1992.

YELLOWFIN SOLE
Eastern Bering Sea

Average catch (1977-92)	= 131,793 t
Long-term potential yield (MSY)	= 155,000-284,000 t
Exploitable biomass (1993)	= 2,504,500 t
Acceptable biological catch (1993)	= 238,000 t
Fishing strategy	= $F_{35\%}$
Abundance and trend	= High and declining
Status of exploitation	= Under-exploited
Importance of recreational fishery	= Nonexistent
Management	= BSAI Groundfish FMP
Age/length at 50% maturity	= Males: 7 years/20.3 cm Females: 8 years/23.8 cm
Age/length at 50% recruitment	= Males: 9 years/26.1 cm Females: 9 years/27.1 cm
Maximum age	= 30 years
Assessment Method	= Age structure model

M = 0.12 $F_{0.1}$ = 0.14 F_{Max} = 0.50 $F_{35\%}$ = 0.118
$F_{1977-92\ average}$ = 0.061 $F_{overfishing}$ = 0.17

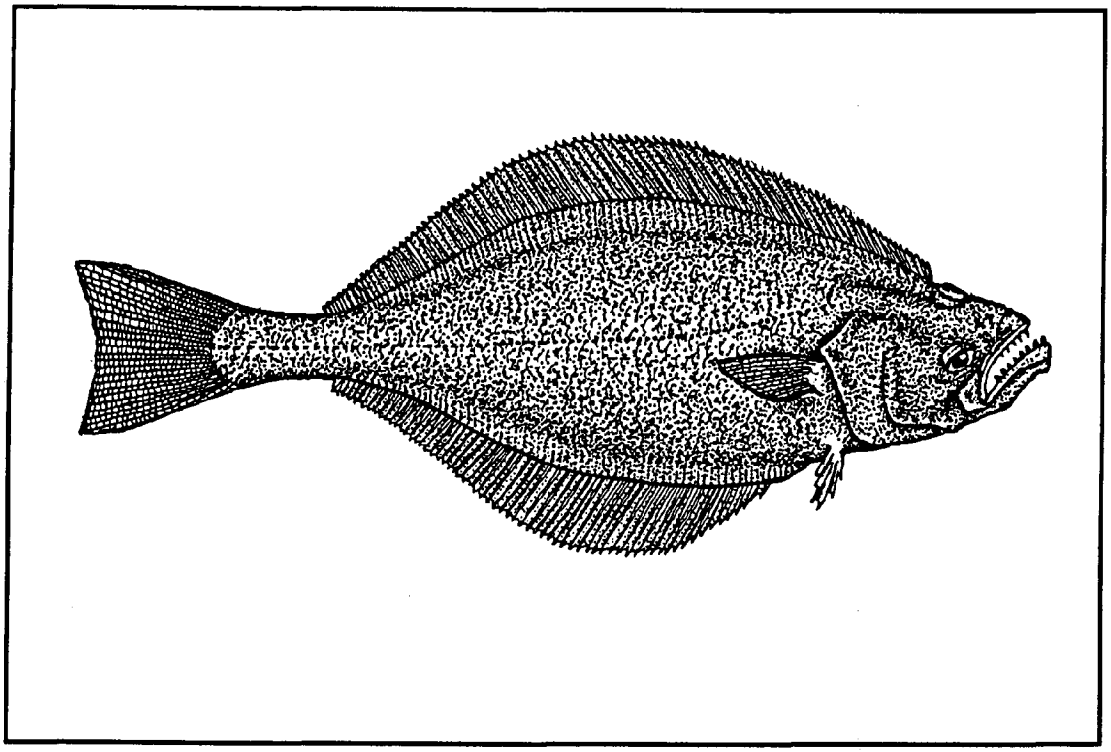
The primary reason for the recovery of the stock during the 1970s and early 1980s was the recruitment of a series of stronger than average year classes spawned in 1968-77. Many of these year classes still support the population and there is good recruitment from some later year classes, particularly 1981, which may be one of the strongest yet observed, and a good 1983 year class. Abundance of eastern Bering Sea yellowfin sole is at a high level and strong incoming year classes should maintain the stock in good condition.

For further information

T. K. Wilderbuer. 1992. Yellowfin sole. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1993. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, AK 99510.

4. GREENLAND TURBOT

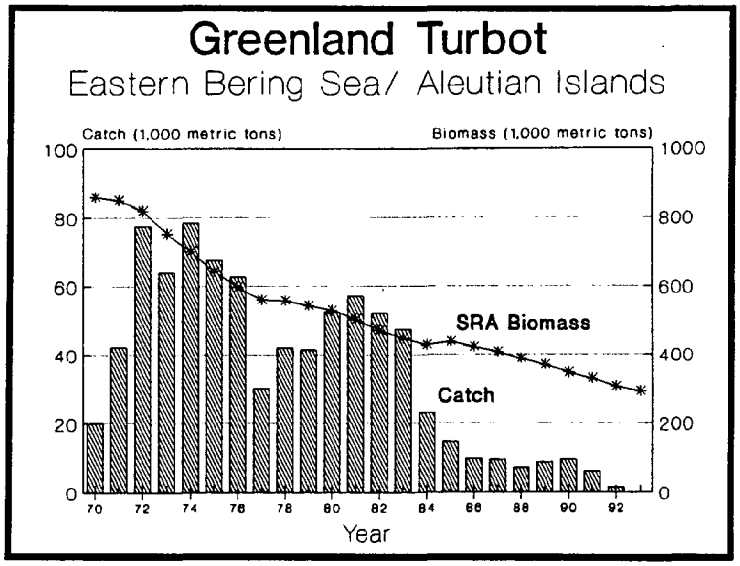
By Thomas K. Wilderbuer and Terrance M. Sample



Greenland turbot (*Reinhardtius hippoglossoides*) are distributed in the Atlantic and Pacific Oceans. In the North Pacific, they are most abundant in the eastern Bering Sea and Aleutian Islands region. It is a demersal flatfish species. Juveniles inhabit the continental shelf waters of the eastern Bering Sea until about 4 or 5 years of age. Older age groups are found in continental slope waters at depths greater than 200 m.

The Greenland turbot is a large flatfish that may live more than 20 years and reach sizes as great as 110 cm and 16-17 kg. Spawning occurs in winter and may be protracted, starting in September or October and continuing until March. Maturity is reached at 5-10 years.

The fishery for Greenland turbot intensified in the early 1970s with annual catches reaching a peak of between 63,000 and 78,000 t from 1972 to 1976. Catches declined in the late 1970s but were still relatively high in 1980-83 with annual catches



GREENLAND TURBOT
Eastern Bering Sea and Aleutian Islands

Average catch (1977-92)	= 25,870 t
Long-term potential yield (MSY)	= 27,100 t
Exploitable biomass (1992)	= 292,500 t
Acceptable biological catch (1992)	= 7,000 t
Fishing strategy	= Bycatch only
Abundance and trend	= Low and decreasing
Status of exploitation	= Fully exploited
Importance of recreational fishery	= Non-existent
Management	= BSAI Groundfish FMP
Age/length at 50% maturity	= 5-10 years/44-57 cm
Age/length at recruitment	= 5 years/44 cm
Maximum age	= At least 20 years
Assessment Method	= Yield per recruit and stock reduction analysis

$M = 0.18$ $F_{0.1} = 0.062$ $F_{MSY} = 0.08$ $F_{1992} = 0.001$
$F_{1977-92} = 0.051$ $F_{overfishing} = 0.068$

ranging from 48,000 to 57,000 t. Catches have continued to decline to less than 10,000 t since 1986. For 1992, no directed fishery was allowed and harvest was bycatch only. This decline is primarily due to catch restrictions placed on the fishery because of continuing poor recruitment observed since 1986.

Results from triennial surveys conducted on the eastern Bering Sea shelf in 1975 and 1979-92 have shown a significant decline in the juvenile population. In addition, surveys of the continental slope indicated strong recruitment of fish less than 55 cm in 1979, and again in 1981-82, but a notable absence of similar-sized fish in later surveys.

Results of comparative trawling between a U.S. research vessel and Japanese commercial vessels indicate that the bottom trawl survey of the continental slope underestimates the biomass of Greenland turbot. Because of this, stock-reduction analysis has been used to estimate the biomass and population trend to evaluate the consequences of various levels of fishing mortality. Results of the analysis suggest that the biomass of Greenland turbot has steadily decreased from virgin levels of over 1 million t in 1960 to 292,500 t in 1993.

GREENLAND TURBOT
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (t)

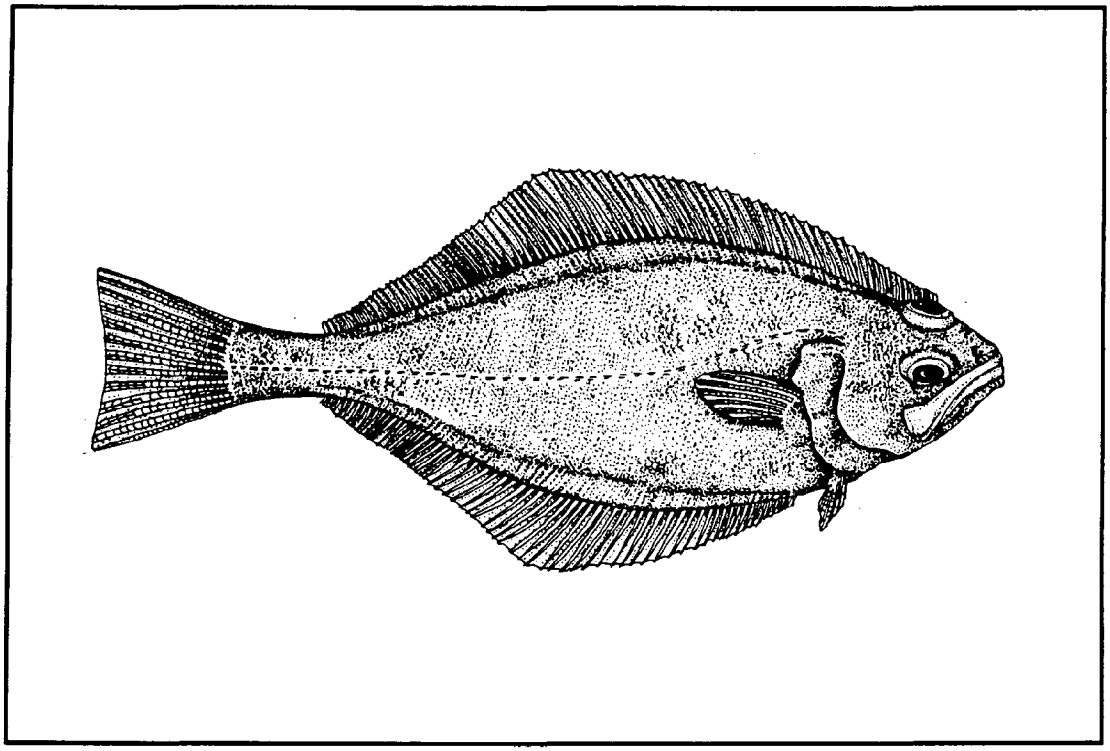
Year	Foreign	Joint Venture	Domestic	Total
1983	47,554	4	0	47,558
1984	23,097	22	0	23,119
1985	14,720	11	0	14,731
1986	6,894	36	2,934	9,864
1987	1,048	59	8,479	9,585
1988	0	88	7,020	7,108
1989	0	50	8,772	8,822
1990	0	1	9,618	9,619
1991	0	0	6,119	6,119
1992	0	0	1,641	1,641

For further information

Wilderbuer, T. K. and T. M. Sample. 1992. Greenland turbot. Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands Region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

5. ARROWTOOTH FLOUNDER

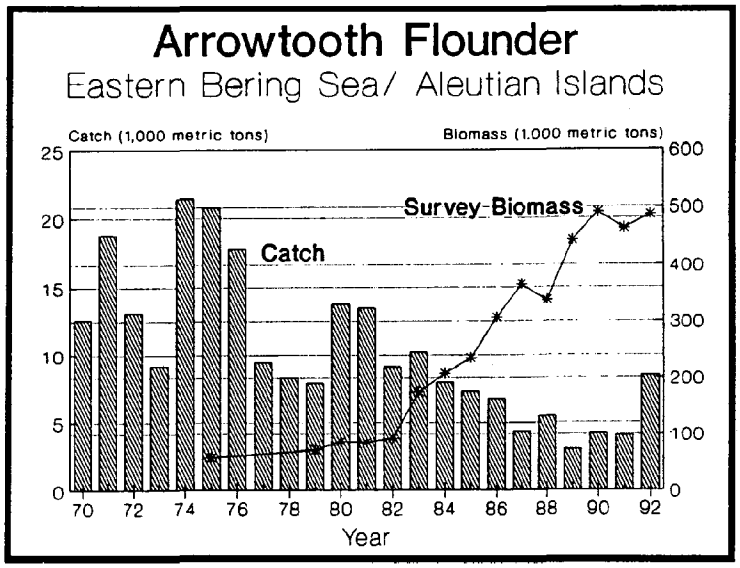
By Terrance M. Sample and Thomas K. Wilderbuer



Arrowtooth flounder (*Atheresthes stomias*) is widely distributed from California to the Gulf of Alaska, and in the central and northern Bering Sea westward to the Asiatic coast.

Arrowtooth flounder is a relatively large flatfish species that occupies continental shelf waters almost exclusively until age 4, and at older ages is found in both shelf and slope waters to depths of 900 m. A maximum length of 84 cm and ages of over 15 years have been observed. Spawning probably occurs from December to February in the Bering Sea.

Arrowtooth flounder is similar in life history, distribution and exploitation to the Greenland turbot. It has been an undesirable commercial species and generally has been taken as bycatch in other target fisheries, mainly in the Greenland turbot fishery. Catches of arrowtooth flounder ranged from 19,000 to 25,000 t during 1974-76. Catches decreased thereafter to 3,000 t in 1990 and 1991



ARROWTOOTH FLOUNDER
Eastern Bering Sea and Aleutian Islands

Average catch (1977-92)	= 9,446 t
Long-term potential yield (MSY)	= 59,000 t
Exploitable biomass (1992)	= 479,700 t
Acceptable biological catch (1993)	= 72,000 t
Fishing strategy	= $F_{35\%}$
Abundance and trend	= High and increasing
Status of exploitation	= Under-exploited
Importance of recreational fishery	= Non-existent
Management	= BSAI Groundfish FMP
Age/length at 50% maturity	= Unknown
Age/length at recruitment	= Male 4 years/29.6 cm Female 4 years/30.4 cm
Maximum age	= At least 20 years
Assessment Method	= Yield per recruit

$M = 0.20$ $F_{0.1} = 0.18$ $F_{Max} = 0.41$ $F_{1992} = 0.018$
$F_{1977-92} = 0.05$ $F_{overfishing} = 0.25$ $F_{35\%} = 0.15$

and were 8,500 t in 1992. This decline is primarily the result of catch restrictions placed on the Greenland turbot fishery and the phasing out of the foreign fishery in the U.S. EEZ. Arrowtooth flounder is underutilized as a commercial species.

Biomass estimates from bottom trawl surveys on the Bering Sea shelf and slope have revealed moderate increases in arrowtooth flounder abundance from 1975 (58,000 t) through 1982 (92,000 t). Significant increases in total biomass have been observed since the early 1980s reaching nearly 490,000 t in 1990 and have remained at this level through 1992. Trawl surveys conducted in the Aleutian Islands Region have indicated that the resource also increased there during the 1980s from 40,400 t in 1980 to 125,700 t in 1986. A series of strong year classes accounts for the increase in abundance and should continue to maintain the overall population abundance at a high level.

ARROWTOOTH FLOUNDER
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (t)

Year	Foreign	Joint Venture	Domestic	Total
1983	13,880	89	0	13,969
1984	9,184	268	0	9,452
1985	6,851	507	17	7,375
1986	3,462	3,376	65	6,903
1987	2,789	1,675	75	4,539
1988	0	2,574	3,309	5,883
1989	0	2,264	958	3,222
1990	0	600	3,572	4,232
1991	0	0	4,069	4,069
1992	0	0	8,516	8,516

For further information

Sample, T. M., and T. K. Wilderbuer. 1992. Arrowtooth flounder. In stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands Region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

6. ROCK SOLE

By Thomas K. Wilderbuer and Gary E. Walters

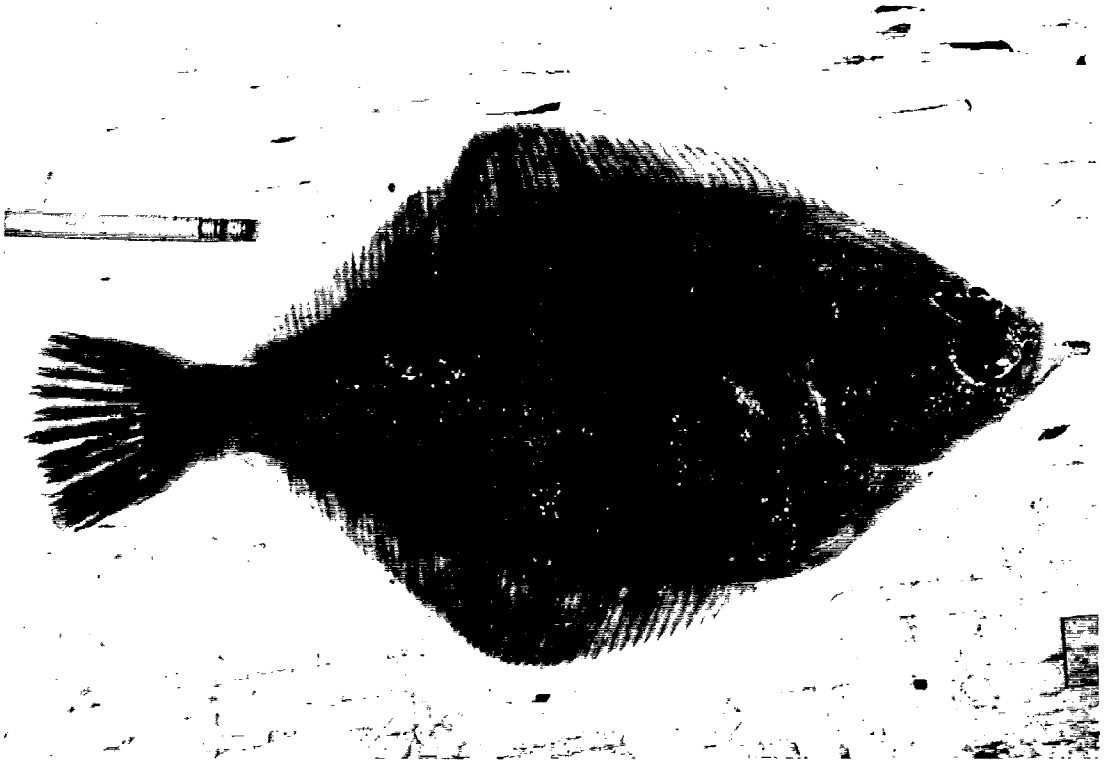
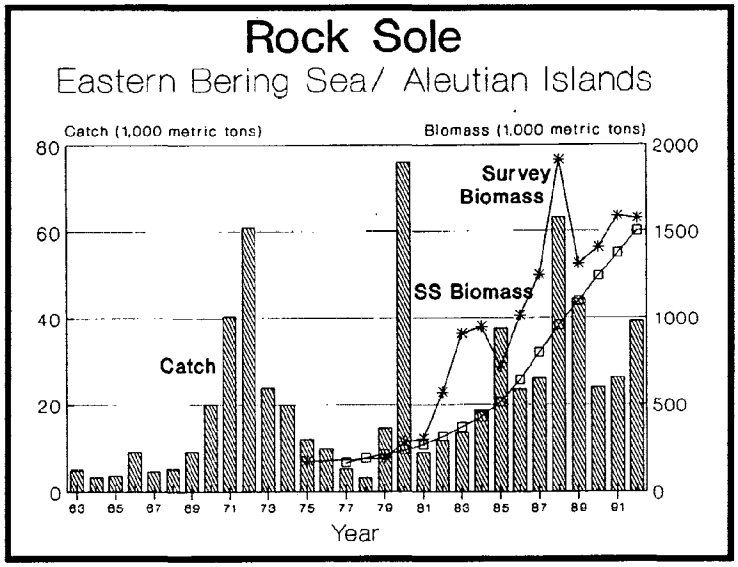


Photo: AFSC

Rock sole (*Pleuronectes bilineatus*) is distributed from southern California (where it is scarce) northward to the Bering and Okhotsk Seas and southward to the Korean peninsula and the Sea of Japan. The largest concentrations are found on the mid-Bering Sea shelf, the center of its distribution. Rock sole is a relatively small flatfish that may attain weights over 1.5 kg and lengths of 53 cm for males and 60 cm for females. Maximum age is at least 25 years. Spawning occurs during winter and early spring with 50% sexual maturity occurring at 29 cm for males and 32-33 cm for females, or at about 8 years of age. Rock sole is one of a few species of flatfish with demersal eggs.

There are three subspecies: *bilineatus bilineata* (Ayers) off the West Coast of North America, *L. bilineatus peracuata* (Cope) of the Gulf of Alaska, Bering and Okhotsk Seas and *L. bilineatus mochigaeri* Snyder of the northwestern Pacific



ROCK SOLE
Eastern Bering Sea

Average Catch (1977-92)	= 22,080 t
Long-term potential yield (MSY)	= 136,400-184,000 t
Exploitable biomass (1992)	= 1,500,500 t
Acceptable biological catch (1993)	= 185,000 t
Fishing strategy	= $F_{35\%}$
Abundance and trend	= High and stable
Status of exploitation	= Underexploited
Importance of recreational fishery	= Non-existent
Management	= BSAI Groundfish FMP
Age/length at 50% maturity	= Males 8 years/29 cm Females 8 years/32-33 cm
Age/length at recruitment	= Males 3 years/14.4 cm Females 3 years/14.3 cm
Maximum age	= At least 25 years
Assessment Method	= Dynamic pool models

$M = 0.2$ $F_{0.1} = 0.159$ $F_{MSY} = 0.176$ $F_{1992} = 0.003$
$F_{1977-92} = 0.029$ $F_{overfishing} = 0.176$ $F_{35\%} = 0.18$

Ocean. Commercial catches of rock sole in the eastern Bering Sea are managed as a unit stock.

With the advent of the yellowfin sole bottom trawl fishery in the late 1950s and early 1960s, rock sole catches occurred first as bycatch, but also as a target species during the roe-bearing season. Catches peaked at nearly 61,000 t in 1972 and then declined to low levels until the late 1980s when a valuable domestic rock sole roe fishery developed, taking over 63,000 t in 1988. This domestic roe fishery is believed to have been worth $25-35 million in 1988. Current catches have remained below this level (40,000 t in 1992) primarily due to the bycatch of valuable halibut and crab species taken in the pursuit of rock sole. Rock sole is currently underutilized with a very low fishing mortality rate.

ROCK SOLE
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (t)

Year	Foreign	Joint Venture	Domestic	Total
1983	4,478	9,140	0	13,616
1984	10,156	27,523	0	37,679
1985	6,671	12,079	0	18,750
1986	3,394	16,217	0	19,611
1987	776	11,136	14,209	26,121
1988	0	40,844	22,374	63,218
1989	0	21,010	23,544	44,554
1990	0	10,492	13,584	24,076
1991	0	0	26,297	26,297
1992	0	0	39,314	39,314

Biomass of rock sole are estimated from bottom trawl surveys, cohort analysis and stock synthesis modeling. Rock sole biomass was relatively stable from 1975 to 1979, but then increased substantially throughout the 1980s from 951,000 t in 1979 to 1.5 million t in 1992. Current biomass may be at or above virgin levels.

The primary reason for the increase in abundance during the 1980s appears to be the recruitment of a series of strong year classes spawned from 1981 to 1987. Trawl survey estimates of age composition in 1991 indicated that 84% of the population numbers were ages 4-8, corresponding to the 1981-87 year classes. This strong recruitment should provide an abundant and stable biomass in the near future.

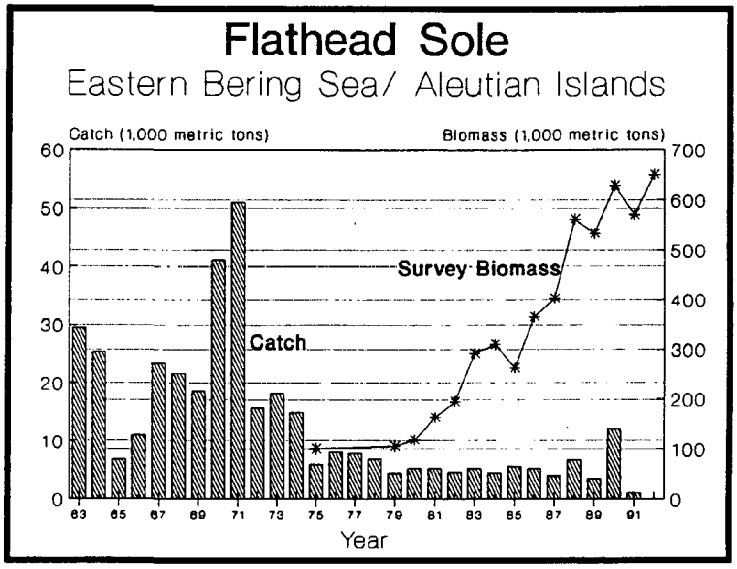
For further information

Wilderbuer, T. K., and G. E. Walters. 1992. Rock sole. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands Region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

7. OTHER FLATFISH

By Gary E. Walters and Thomas K. Wilderbuer

The "other flatfish" complex of species is a category of flatfish created for management purposes. This category is made up primarily of two species, flathead sole (*Hippoglossoides elassodon*) and Alaska plaice (*Pleuronectes quadrituberculatus*), but also includes several others such as rex sole (*Errex zachirus*), Dover sole (*Microstomias pacificus*), starry flounder (*Platichthys stellatus*), longhead dab (*Pleuronectes proboscidea*), and butter sole (*Pleuronectes isolepis*). With the exception of Alaska plaice and flathead sole, these species are not abundant in the eastern Bering Sea.



OTHER FLATFISH
Eastern Bering Sea and Aleutian Islands

	Flathead Sole	Alaska Plaice
Average catch (1982-91)	= 5,250 t	22,420 t
Long-term potential yield (MSY)	= 65,100 t	76,600 t
Exploitable biomass (1992)	= 650,100 t	562,400 t
Acceptable biological catch (1993)	= 105,600 t	77,300 t
Fishing strategy	= $F_{35\%}$	$F_{35\%}$
Abundance and trend	= High and increasing	High and stable
Status of exploitation	= Underexploited	Underexploited
Importance of recreational fishery	= None	None
Management	= BSAI Groundfish FMP	
Age/length at 50% maturity	= Unknown	Females 9 yrs/31 cm
Age/length at recruitment	= 3 yrs/17 cm	4 yrs/13 cm
Maximum age	= 20+ years	23+ years
Assessment Method	= Yield per recruit	
M	= 0.2	0.2
F (0.1)	= 0.159	0.159
F (MSY)	= 0.176	0.176
F (1992)	= 0.002	0.003
F (1977-91)	= 0.023	0.031
F (overfishing)	= 0.23	0.2
$F_{35\%}$	= 0.193	0.167

OTHER FLATFISH
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (1,000 t)

Category	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Flathead Sole										
Foreign	4.3	4.4	3.6	2.6	0.7	0.2	0	0	0	0
Joint Venture	0.2	0.8	0.9	3.1	4.5	3.7	6.8	3.5	2.2	0
Domestic	0	0	0	0	0	0.01	0	0.02	9.9	1.1
Total	4.5	5.2	4.5	5.7	5.2	3.9	6.8	3.5	12.1	1.1
Alaska Plaice										
Foreign	6.6	9.1	15.1	11.3	6.2	0.8	0	0	0	0
Joint Venture	0.2	1.6	3.7	13.6	40.3	17.5	61.7	13.8	15.9	0
Domestic	0	0	0	0	0	0.05	0	0.07	4.8	1.8
Total	6.8	10.7	18.8	24.9	46.5	18.4	61.7	13.9	20.7	1.8

Flathead sole

Flathead sole range from Point Reyes, California, along the U.S. West Coast and British Columbia into the Gulf of Alaska, Bering Sea, Aleutian Islands, and the Kuril Islands. It is by far most abundant on the eastern Bering Sea shelf, occurring at bottom depths between 100 and 250 m. Flathead sole is a relatively small-sized flatfish and may attain lengths up to 49 cm for males and 52 cm for females, and weights of 1.2 to 1.5 kg, respectively. Most females mature by age 2, but whether or not spawning occurs at this age is unknown. Spawning occurs during the spring.

Flathead sole are managed by the NPFMC as one stock unit in the Bering Sea. It is of limited commercial importance and are usually caught as bycatch in the yellowfin sole and rock sole (roe) trawl fisheries. Catches from 1963 to 1980 averaged 18,400 t annually with a peak of 51,000 t occurring in 1971. Catches since 1980 have averaged only 5,070 t. Flathead sole are underexploited in the Bering Sea.

Bottom trawl surveys conducted by the NMFS in the eastern Bering Sea indicate that the flathead sole resource has increased from 100,000 t in 1975 to over 650,000 t in 1992. This increase appears to be the result of a series of consecutive strong year classes spawned in the late 1970s and early 1980s.

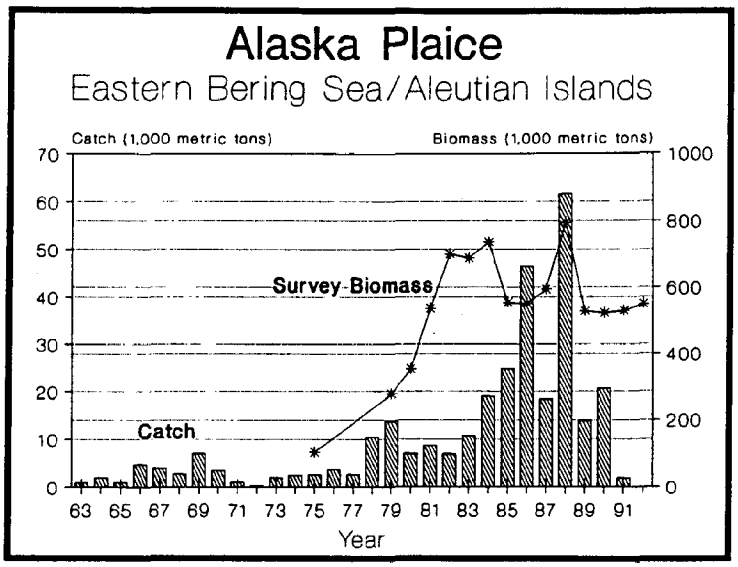
Alaska plaice

Alaska plaice range from the Gulf of Alaska to the Bering and Chukchi Seas and south into Asian waters to the Sea of Japan, including the Okhotsk Sea to as far south as Peter the Great Bay. In the eastern Bering Sea, where Alaska plaice is most abundant, it is almost entirely limited to continental shelf waters with a distribution similar to yellowfin sole. The highest concentrations are found on the middle shelf area southeast of St. Matthew Island primarily at depths less than 150 m. Alaska plaice are a relatively large flatfish and may reach a length of 60 cm and an age of over 20 years. Alaska plaice spawn from April to June on hard, sandy substrates with females reaching 50% maturity at 31 cm, which corresponds to an age of 9 years.

Commercial fisheries catch information reported by foreign fleets during the 1960s indicated that Alaska plaice was not sought after and was lightly exploited. Although not a target species, it is believed that substantial unreported removals of Alaska plaice occurred in the intensive yellowfin sole fishery during the 1960s and may have contributed to a population decline. In 1975, when Bering Sea trawl surveys were initiated, Alaska plaice biomass was estimated at 103,500 t, the lowest level observed during the time series. Catches since the implementation of the Magnuson FMCMA in 1977

have increased to a high of 61,600 t in 1988 and have averaged only 16,800 t ($F_{1977-91}$ = 0.032). Alaska plaice are currently underexploited.

Bottom trawl surveys indicated that Alaska plaice biomass increased from a low of 103,500 t in 1975 to 734,400 t in 1984. Since 1984, the biomass has remained stable between 525,000 and 600,000 t. The increase during the late 1970s to early 1980s was caused by a series of stronger than average year classes from 1973 to 1976.

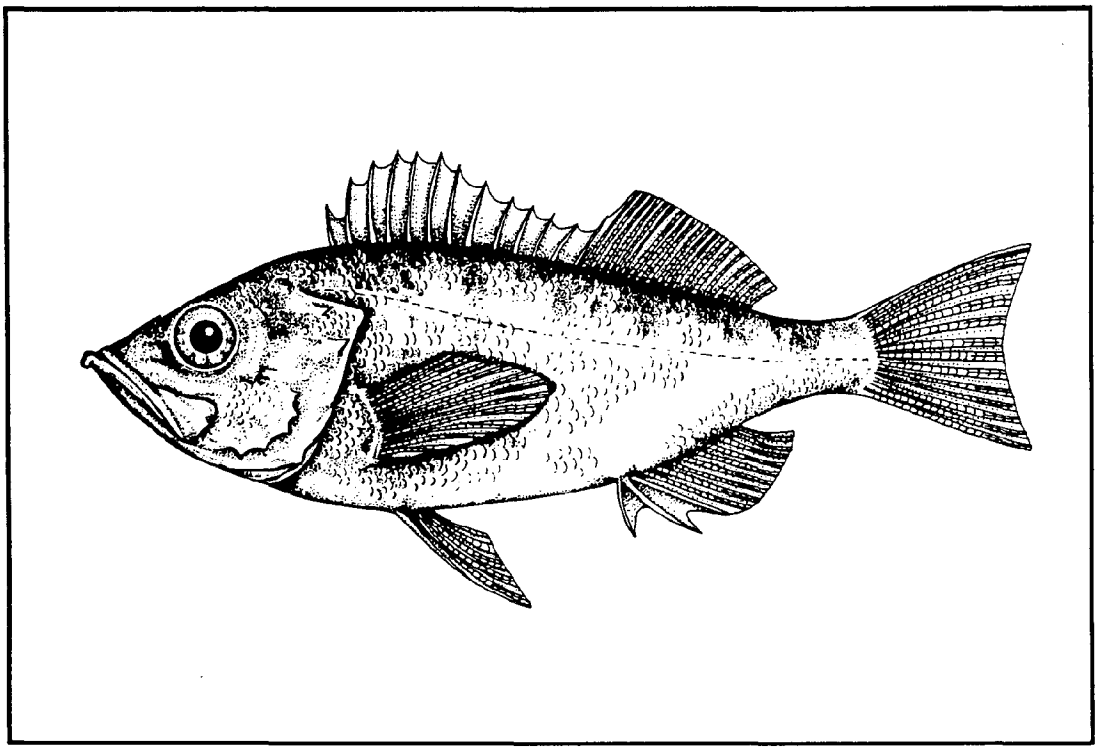


For further information

Walters, G. E., and T. K. Wilderbuer. 1992. Other flatfish. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands Region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

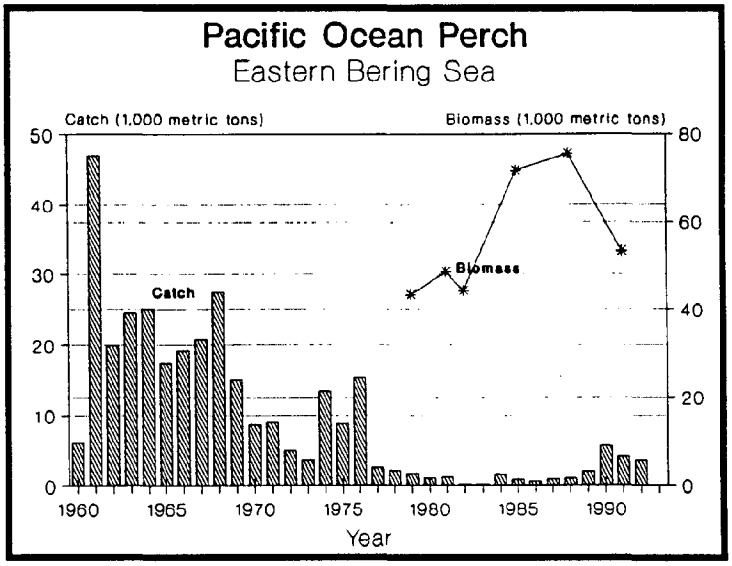
8. PACIFIC OCEAN PERCH

By Daniel H. Ito and James N. Ianelli



Pacific ocean perch (*Sebastes alutus*) inhabit the outer continental shelf and upper slope regions of the North Pacific Ocean and Bering Sea regions. Two main stocks of Pacific ocean perch have been identified in the region--an eastern Bering Sea slope stock and an Aleutian Islands stock.

For management purposes, four other associated species of rockfish (northern rockfish, *S. polyspinis*; rougheye rockfish, *S. aleutianus*; shortraker rockfish, *S. borealis*; and sharpchin rockfish, *S. zacentrus*) are managed as a part of the Pacific ocean perch complex. For the eastern Bering Sea slope region, the POP complex was divided into two subgroups: 1) Pacific ocean perch and 2) shortraker, rougheye, sharpchin, and northern rockfishes combined. For the Aleutian Islands region, the POP complex was divided into three subgroups: 1) Pacific ocean perch, 2) shortraker and rougheye rockfishes, and 3) sharpchin and northern rockfish. These subgroups were established by the NPFMC to



PACIFIC OCEAN PERCH
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (t)

	Eastern Bering Sea				Aleutian Islands			
Year	Foreign	JV	DAP	Total	Foreign	JV	DAP	Total
1983	116	97	8	221	272	8	--	280
1984	156	134	1,279	1,569	356	273	2	631
1985	35	32	717	784	Tr	215	93	308
1986	16	117	427	560	Tr	160	126	286
1987	5	50	875	930	0	500	504	1,004
1988	0	51	996	1,047	0	1,513	466	1,979
1989	0	31	1,986	2,017	0	0	2,706	2,706
1990	0	0	5,639	5,639	0	0	14,650	14,650
1991	0	0	4,083	4,083	0	0	4,000	4,000
1992	0	0	3,540	3,540	0	0	11,700	11,700

JV = Joint Venture DAP = Domestic Annual Processing

protect individual low catch-quota species from possible overfishing.

Of the five species which comprised the Pacific ocean perch complex, *S. alutus* has historically been the most abundant and has contributed most to the commercial rockfish catch. Furthermore, the bulk of the research on rockfish has concentrated on Pacific ocean perch; little biological or assessment information is available for the other species. Consequently, this synopsis deals primarily with Pacific ocean perch.

Pacific ocean perch are usually associated with trawlable cobble substrate. A demersal species, it can be found at depths ranging from 50 to 700 m, with commercial quantities generally occurring between 100 and 400 m.

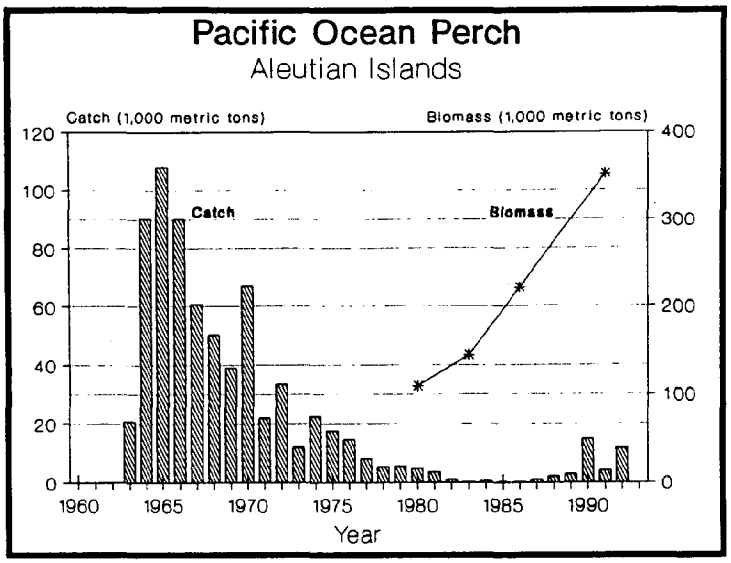
Pacific ocean perch are slow-growing and long-lived. Longevity has been estimated at 90 years. The natural mortality rate equals 0.05. This species begins to recruit to the commercial fishery at about age 5 and is fully recruited by age 10, corresponding

PACIFIC OCEAN PERCH
Eastern Bering Sea and Aleutian Islands

Average Catch: Eastern Bering Sea (EBS)		= 1,883 t
(1977-92)	Aleutian Islands (AI)	= 4,108 t
Long-term potential yield: EBS		= 4,600 t
	AI	= 10,300 t
Acceptable biological catch (1993): EBS		= 3,300 t
	AI	= 13,870 t
Exploitable biomass (1993): EBS		= 59,700 t
	AI	= 260,300 t
Fishing strategy		= $F_{35\%}$
Age at recruitment		= 5-10 years
Length at recruitment		= 26-32 cm
Maximum age		= 90 years
Abundance and trend		= Moderate and increasing
Importance of recreational fishery		= None
Management		= BSAI Groundfish FMP
Status of exploitation		= Fully exploited

$M = 0.05$ $F_{0.1} = 0.06$ $F_{MSY} = 0.06$
$F_{overfishing}$ = unknown $F_{1977-92\ average} = <0.06$

with fork lengths of about 26 and 32 cm, respectively. Although the maximum recorded length is 54 cm, the bulk of the commercial catch is comprised of individuals ranging from 25 to 45 cm. Females are viviparous, retaining eggs in the ovary after fertilization until the yolk sac is absorbed. Mating takes place in late fall or early winter, with subsequent larval extrusion occurring in late winter or early spring.



Very little biological information is available for the four other species within the POP complex. Preliminary information suggests, however, that they are also slow-growing and long-lived. Maximum reported ages for rougheye and shortraker rockfish are 140 and 120 years, respectively. Natural mortality is probably about 0.05 or less, suggesting very low rates of productivity.

Pacific ocean perch were highly sought after by Japanese and Soviet fisheries and supported a major trawl fishery throughout the 1960s and early 1970s. Catches in the eastern Bering Sea peaked at 47,000 t in 1961; the peak catch in the Aleutian Islands region occurred in 1965 at 109,100 t. Soon after, the catches declined rapidly. With such long life spans and low rates of natural mortality and growth, Pacific ocean perch were apparently unable to sustain such large removals from their populations.

With the implementation of the MFCMA in 1977, the foreign fisheries were gradually phased out. Coincident with this reduction in foreign fishing, a significant domestic rockfish fishery developed. The domestic fishery started out as joint ventures with foreign companies in the mid-1980s and has now become a totally domestic industry. The domestic fishery is primarily composed of factory trawlers that harvest and process the fish at sea. Although Pacific ocean perch has been the primary target of the rockfish fishery, recent fisheries also target on shortraker and rougheye rockfish. These species are larger than Pacific ocean perch and inhabit deeper waters (>300 m) of the continental slope.

Stock assessments based on catch-per-unit-effort (CPUE) data from Japanese trawlers indicate that stock abundance declined to very low levels in all regions. By 1977, CPUE values had dropped by more than 90-95% from those of the early 1960s, suggesting a depressed stock condition. Since then, the stocks have shown signs of rebuilding.

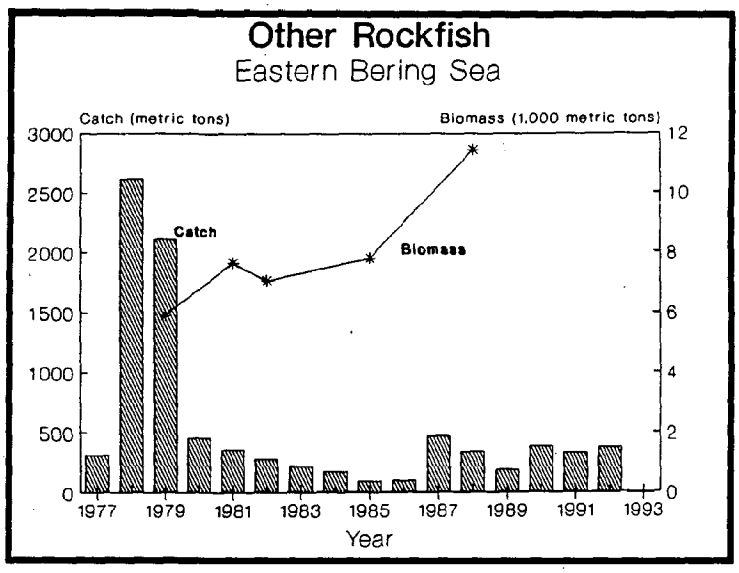
Based on results from comprehensive age-structured modeling (stock synthesis), the current (1993) estimate of exploitable biomass for Pacific ocean perch is 59,700 t for the eastern Bering Sea stock and 260,300 t for the Aleutian Islands stock. The stock in the eastern Bering Sea appears to have stabilized, whereas, the Aleutian Islands stock appears to be increasing in abundance. The most recent estimates of exploitable biomass for the other four species in the complex are 29,700 t in the eastern Bering Sea and 139,500 t in the Aleutian Islands. In both regions, recent analyses have concluded that the recruitment of Pacific ocean perch is highly variable.

For further information

Ianelli, J.N., and D.H. Ito. 1992. Pacific ocean perch. In Stock assessment and fishery evaluation document for groundfish resources of the Bering Sea/Aleutian Islands region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

9. OTHER ROCKFISH

By Daniel H. Ito



The category "other rockfish", includes *Sebastolobus* spp. and all species of *Sebastes* other than the Pacific ocean perch complex. For management purposes, the other rockfish resource is assumed to consist of two separate groups: the eastern Bering Sea group and the Aleutian Islands group. Information on biological parameters is lacking for these groups of rockfishes.

Since implementation of the MFCMA, the peak catch (2,600 t) of other rockfish in the eastern Bering Sea occurred in 1978. In the Aleutian Islands region, the peak removal occurred 1 year later in 1979 with a harvest of about 4,500 t. Catches in recent years have been minor and are mainly incidental to other directed fisheries. The average catch during 1977-91 amounted to about 560 t from the eastern Bering Sea region and 1,000 t from the Aleutian Islands region.

Cooperative U.S.-Japan trawl surveys conducted from 1979 to 1988 provided the estimates of absolute biomass. The best estimate of current exploitable biomass for other rockfish is about 8,000 t for the eastern Bering Sea stock and 18,500 t for the Aleutian Islands stock. The estimates, however, have very wide confidence intervals.

Information is not available to estimate MSY. However, if one assumes that the exploitation and

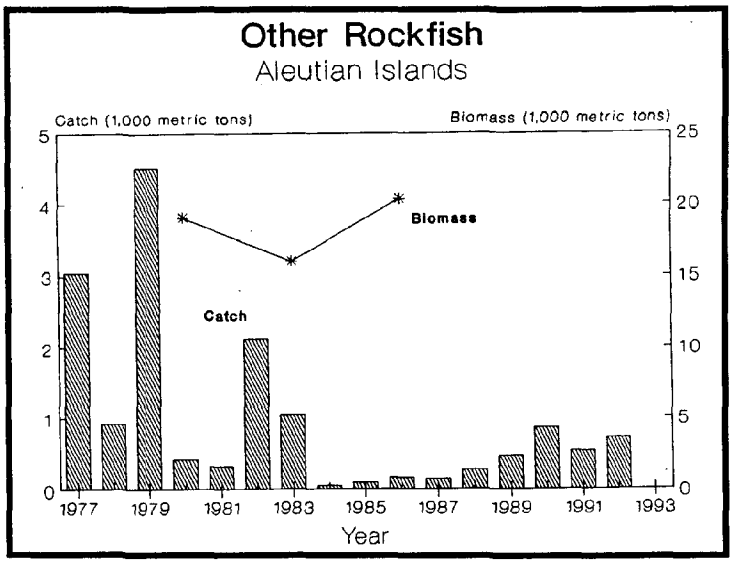
OTHER ROCKFISH
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (t)

	Eastern Bering Sea				Aleutian Islands			
Year	Foreign	JV	DAP	Total	Foreign	JVP	DAP	Total
1983	212	8	--	220	1,041	4	--	1,045
1984	121	8	47	176	42	14	--	56
1985	33	3	56	92	2	14	83	99
1986	4	12	86	102	Tr	15	154	169
1987	3	4	467	474	0	6	141	147
1988	0	8	333	341	0	68	210	278
1989	0	4	188	192	0	0	481	481
1990	0	0	384	384	0	0	864	864
1991	0	0	328	328	0	0	541	541
1992	0	0	376	376	0	0	699	699

JVP = Joint venture DAP = Domestic annual processing

productivity patterns for other rockfish are similar to those of *S. alutus*, LTPY has beeen estimated at about 400 t for the eastern Bering Sea and 900 t for the Aleutian Islands region.

It is assumed that the same exploitation rate used to estimate the ABC for Pacific ocean perch (*S. alutus*) is applicable for estimating ABC for other rockfish. Multiplying M equals 0.05 by the current exploitable biomass, yields ABC values of 400 t for the eastern Bering Sea stock and 925 t for the Aleutian Islands stock.



For further information

Ito, D.H. 1992. Other rockfish. In Stock assessment and fishery evaluation document for groundfish resources of the Bering Sea/Aleutian Islands region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

OTHER ROCKFISH
Eastern Bering Sea (EBS) and Aleutian Islands (AI)

Average catch: Eastern Bering Sea (EBS)		=	550 t
(1977-92)	Aleutian Islands (AI)	=	980 t
Long-term potential yield: EBS		=	400 t
	AI	=	900 t
Acceptable biological catch (1993): EBS		=	400 t
	AI	=	925 t
Exploitable biomass (1993): EBS		=	8,000 t
	AI	=	18,500 t
Fishing strategy		=	F = M
Age/length at recruitment		=	Unknown/unknown
Maximum age		=	Unknown
Abundance and trend		=	Unknown
Importance of recreational fishery		=	None
Management		=	BSAI Groundfish FMP
Status of exploitation		=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{MSY} = Unknown
$F_{overfishing}$ = Unknown $F_{1977-92\ average}$ = Unknown

10. ATKA MACKEREL

By Sandra A. Lowe

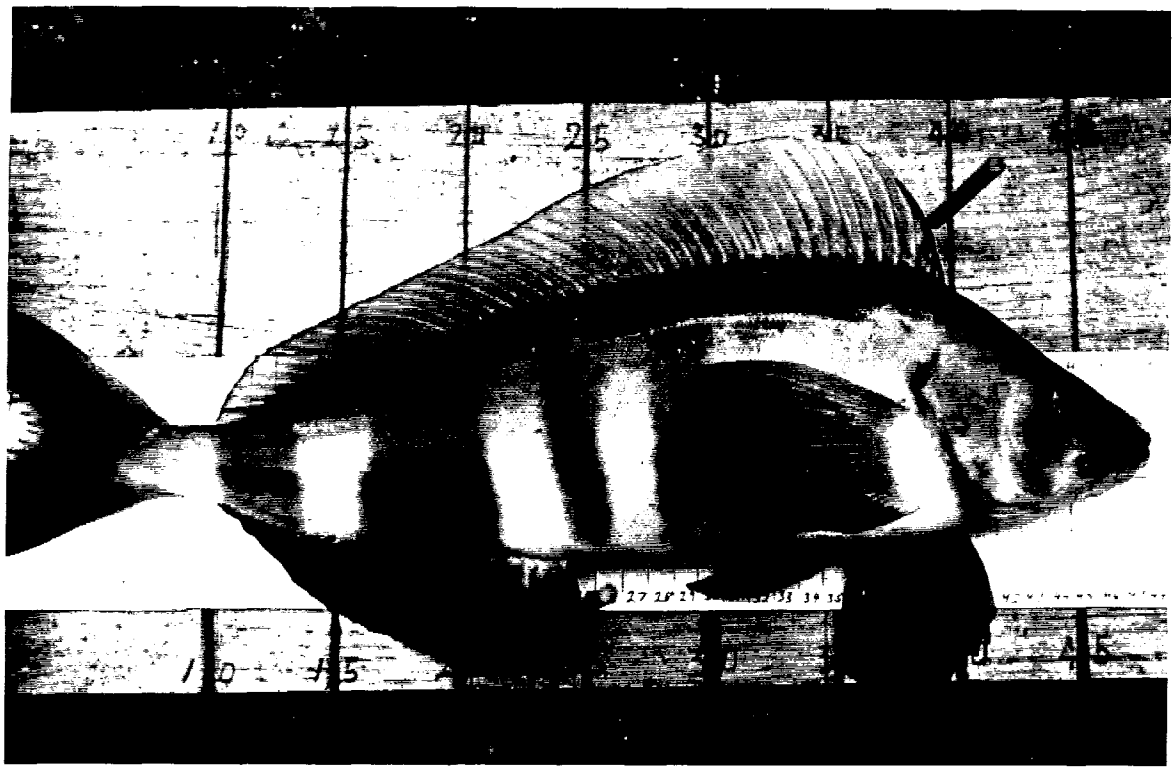
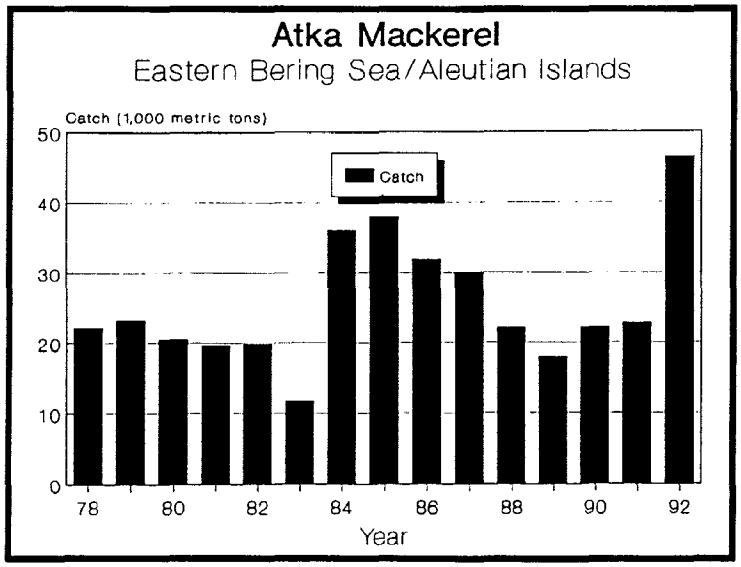


Photo: AFSC

Atka mackerel *Pleurogrammus monopterygius* is a semidemersal species. The species is found from the east coast of the Kamchatka Peninsula, throughout the Komandorskiye and Aleutian Islands, north to the Pribilof Islands in the eastern Bering Sea, and eastward through the Gulf of Alaska to Southeast Alaska. Its center of abundance is in the Aleutian Islands. Atka mackerel range from the lower intertidal area to depths of 575 m, but over 95% of their occurrences have been at depths less than 300 m. Both sexes mature at 3-4 years of age at a size of 31-33 cm. Atka mackerel commonly attain sizes up to 45 cm and 1.1 kg in weight. The maximum age is 14 years, although the bulk of the catch has consisted of fish 3-7 years old. Spawning generally occurs during June-September at depths of 5-30 m.

Atka mackerel of the Gulf of Alaska and the Aleutian Islands region are thought to belong to separate stocks. Commercial fisheries for Atka mackerel in the Bering Sea/Aleutian Islands region



ATKA MACKEREL
Eastern Bering Sea and Aleutian Islands

Average catch (1978-92)	= 25,900 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 117,100 t
Age/length at recruitment	= 3 years/30 cm
Maximum observed age	= 14 years
Abundance and trend	= High, stable
Exploitable biomass	= High
Harvest strategy	= F = M
Importance of recreational fishery	= None
Management	= BSAI Groundfish FMP
Assessment Method	= Age structured
Status of exploitation	= Underexploited

M = 0.30 $F_{0.1}$ = 0.324 F_{MSY} = Unknown

$F_{overfishing}$ = 0.506 $F_{1977-92\ ave}$ = 0.027

are managed under the NPFMC's Bering Sea-Aleutian Islands groundfish FMP. In the Gulf of Alaska, Atka mackerel are less abundant and are included within the "other species" category for management under the Gulf of Alaska groundfish FMP. This species is not an important recreational species.

Until 1980, Atka mackerel was harvested by foreign fisheries. U.S. joint venture fisheries then dominated the catches from 1982 to 1988. Since then, the fishery has become exclusively domestic. From 1979 to 1982 catches declined gradually (23,300 t to 19,900 t), then dropped sharply to 11,700 t in 1983. The decline was due to changes in the target species and allocation issues rather than changes in stock abundance. From 1984 to 1987, catches were at record high levels, averaging 34,000 t annually. A strong 1977 year class, which recruited to the fishery in 1980, supported the fishery throughout the 1980s. The commercial fisheries can occur year-round, but the peak of the fishery has generally been from April to August. In 1992, Atka mackerel landings totaled 46,400 t and had an ex-vessel value of $12.8 million.

Atka mackerel occur in large, localized concentrations making them an especially difficult species to survey with trawls. They are also difficult to survey with hydroacoustic gear because they are poor acoustic targets. Because of survey difficulties, a stock synthesis model was used to assess the status of Atka mackerel. The model projected a high level of exploitable biomass for 1993 of approximately 1.2 million t. In addition, it predicts good recruitment from the 1988 and 1989 year classes in order to produce the level of biomass seen in the 1991 survey. Length frequency and age composition data from the 1991 survey corroborated the presence of a strong 1988 year class; however, this year class was not yet apparent in the commercial fishery. Good recruitment combined with low levels of exploitation indicate that the stock is in good shape and at a high abundance level.

An estimate of a stock-recruitment relationship is required to calculate MSY and its corresponding fishing mortality rate (F_{msy}). Although there is recruitment information for Atka mackerel, a stock-recruitment relationship could not be inferred from the data. MSY is therefore unknown. As an alternative to F_{msy}, a yield-per-recruit model was used to determine the $F_{0.1}$ level. The $F_{0.1}$ level was determined to equal 0.324. Another study found that when uncertainty is directly incorporated into the estimation of stock abundance and recruitment, the optimal fishing mortality rates would be less than those derived from deterministic models for sustainable yield (e.g., $F_{0.1}$). A lower harvest rate of 30% (F = M) was therefore recommended and multiplied by exploitable biomass to obtain an ABC of 351,300 t. Because of uncertainties in the estimation of biomass, the NPFMC decided to step up the use of the available ABC in 6 equal increments (58,550 t), beginning with the 1992 fishery. Thus, the ABC for

the 1993 fishery was 117,100 t. The fishing mortality associated with a catch of 117,100 t is 0.073; well below the overfishing level. The overfishing level is defined as the fishing mortality rate that results in the biomass-per-recruit ratio falling to 30% of its pristine level. This rate has been determined to be F = 0.506 and is associated with a harvest level of 771,100 t.

ATKA MACKEREL
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH (t)

Year	Foreign	Joint Venture	Domestic	Total
1983	1,214	10,512	0	11,726
1984	112	35,943	0	36,055
1985	1	37,859	0	37,860
1986	6	31,984	0	31,990
1987	0	30,061	0	30,061
1988	0	19,620	2,465	22,084
1989	0	56	17,938	17,994
1990	0	0	22,205	22,205
1991	0	0	22,840	22,840
1992	0	0	46,226	46,226

The ABC of 117,100 t is based on an analysis for the entire Aleutian region. The bulk of the fishery occurs in the eastern Aleutian Islands region, whereas the bulk of the biomass has been found in the western region, particularly the southwest region. To avoid localized depletion of the resource, the catch should be apportioned throughout its range according to the distribution of biomass. Because of administrative inability to apportion catches in the Aleutian management district at this time, the 1993 TAC for the entire Aleutian Islands region was set at only 32,000 t, an amount appropriate only for the eastern portion of the Aleutian Islands region where most of the fishing occurs. An amendment to the FMP has already been submitted to divide the Aleutians into three subareas so that catch quotas can be assigned to spread out the fishing effort in future years.

For further information

Lowe, S. A. 1992. Atka mackerel. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1993. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

Methot, R. D. 1990. Synthesis model: An adaptable framework for analysis of diverse stock assessment data. INPFC Bull. 50:259-277.

11. SQUID AND OTHER SPECIES

By Loh-Lee Low

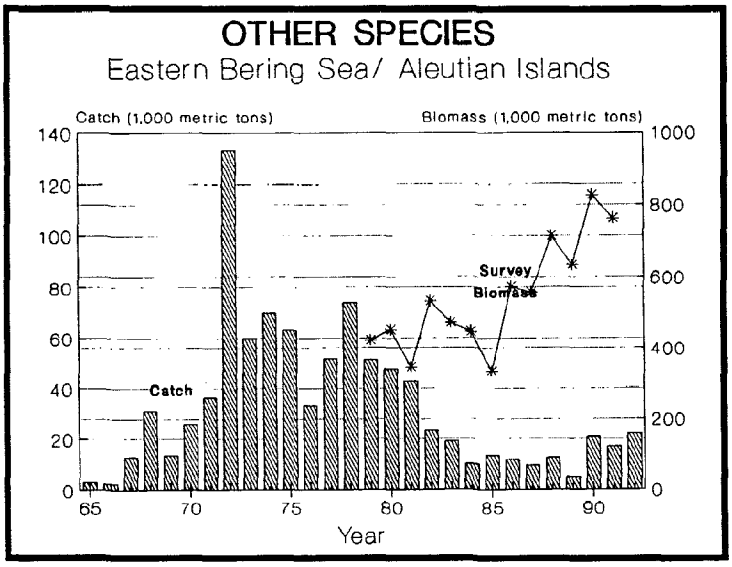
Photo: AFSC

Squid

Two species of squid are harvested: the red squid (*Berryteuthis magister*) in the eastern Bering Sea, and the boreal clubhook squid (*Onychoteuthis borealijaponicus*) in the Aleutian Islands region. Both species are distributed across the North Pacific Ocean from Asia to North America. The red squid is more northerly distributed, being found throughout the Bering Sea north to the Bering Strait. The northward distribution of the boreal clubhook squid is limited to the southern Bering Sea. Both species inhabit pelagic waters.

The life span of the two species is about a year. The red squid reaches a maximum mantle length of 25 cm; the boreal clubhook squid reaches a maximum mantle length of 37 cm in females and 30 cm in males.

Squid were ocassionally targeted by foreign fisheries in the past. During these periods, catches peaked at 9,000 t in 1978. Following 1985, as foreign fisheries got phased out of the U.S. EEZ and



replaced by U.S. fisheries, catches of squids dropped to a few hundred tons annually, mainly as incidental catches.

Assessment data for squid are not available because little research has been directed to it. The squid resource is believed to be large because of its low position in the trophic chain and light degree of exploitation. MSY and ABC for squid are unknown but are believed to be at least equal to the highest catch on record (10,000 t).

Other Species

The "other species" category covers species that are currently of little economic value and not targeted upon but have potential economic value or are important components of the ecosystem. The taxonomic groups are sculpins (Cottidae), skates (Rajidae), smelts (Osmeridae), sharks (Squalidae) and octopus (Octopodidae). There were 38 species of sculpins identified in the Bering Sea/Aleutian Islands region. At least five species of skates, three species of sharks, three species of smelts, and two species of octopus are found in this region.

Catches of "other species" increased during the 1960s and early 1970s reaching a peak of 133,000 t in 1972. Catches declined to a low of 5,000 t in 1989 as domestic fisheries displaced foreign and joint-venture fisheries. Catches have since stabilized at 17,000 - 22,000 t during 1990-92.

Stock assessments of the "other species" category are based on trawl survey data. The data show that the main species taken by bottom trawls are sculpins and skates. These two groups comprise 95-99% of the total biomass of the "other species" category since 1981. Some other species, however, are believed to be poorly sampled by bottom trawls, particularly those distributed inshore and in the pelagic zone.

Surveys indicate that sculpins were the largest component of the category until 1986, when skate biomass increased and exceeded that of sculpins. The increase resulted in higher total biomass for the "other species" category: from 345,000-460,000 t in 1979-81 to 632,000-827,000 t in 1988-90.

The condition of the resource appears good and exploitation is well below its biological productivity. Based on average catches, MSY and ABC are both estimated at 62,900 t. The NPFMC has set its ABC at 27,200 t for 1992 and 26,600 t for 1993 to accomodate expected catches by the fisheries.

SQUID and OTHER SPECIES
Eastern Bering Sea and Aleutian Islands
COMMERCIAL CATCH

Year	Foreign	Joint-Venture	Domestic	Total
SQUID (in t)				
1983	3,970	10	0	3,980
1984	3,133	34	0	3,167
1985	1,588	32	0	1,620
1986	830	38	0	868
1987	96	35	1	132
1988	0	171	246	417
1989	0	107	199	306
1990	0	0	626	626
1991	0	0	632	632
1992	0	0	544	544
OTHER SPECIES (in t)				
1983	14,255	1,578	3,307	19,140
1984	7,533	2,645	--	10,178
1985	6,283	6,343	927	13,553
1986	4,044	7,557	379	11,980
1987	2,673	6,121	930	9,724
1988	0	11,840	803	12,643
1989	0	4,696	405	5,101
1990	0	0	20,808	20,808
1991	0	0	17,199	17,199
1992	0	0	22,154	22,154

For further information

Bakkala, R. G. 1991. Squid and other species, p. 31-32. In Loh-Lee Low [ed.]. Status of living marine resources off Alaska as assessed in 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/NWC-211.

OTHER SPECIES
Eastern Bering Sea and Aleutian Islands

Average catch (1977-92)	=	27,200 t
Long-term potential yield (MSY)	=	62,900 t
Exploitable biomass (1993)	=	780,000 t
Acceptable biological catch (1993)	=	26,600 t
Fishing strategy	=	F = M
Abundance and trend	=	High and increasing
Status of exploitation	=	Underexploited
Importance of recreational fishery	=	None
Management	=	BSAI Groundfish FMP
Assessment Method	=	Survey biomass

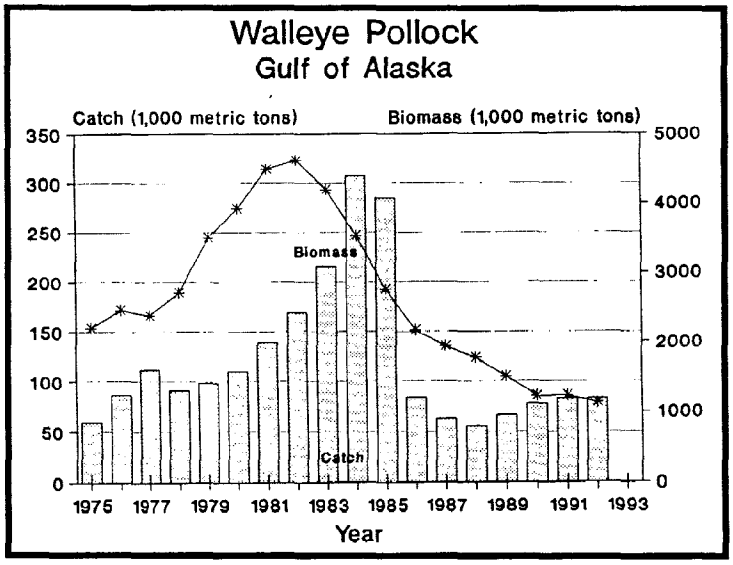
12. WALLEYE POLLOCK

By Anne B. Hollowed

Photo: AFSC

Walleye pollock (*Theragra chalcogramma*) is a semidemersal schooling fish that is widely distributed throughout North Pacific temperate and subarctic waters. Pollock consume a wide variety of prey in the Gulf of Alaska. In 1990, euphausiids, shrimp, and capelin (*Mallotus villosus*) were the principal prey items (by weight) consumed by pollock during the summer months. Pollock can attain lengths of 80 cm; however, the majority of mature pollock range between 40 and 65 cm in length. The maximum age recorded for Gulf of Alaska pollock is in excess of 18 years, although most pollock are less than 11 years old. Sexual maturity is attained between ages 3 to 6; spawning occurs during the winter and early spring.

In the Gulf of Alaska, major exploitable concentrations of pollock are found primarily in the NPFMC's central and western regulatory areas (long. 147°-170°W). Pollock from these regions are managed as a unit stock because they are considered separate from



those in the Bering Sea, the Aleutian Islands region, and the eastern Gulf of Alaska.

Shelikof Strait is a major pollock spawning area in the Gulf of Alaska, although other spawning locations in the western and central areas have been identified from the occurrence of eggs and larvae as well as observations of spawning fish. In previous years, these areas were judged to be of minor importance relative to the Shelikof Strait spawning area.

WALLEYE POLLOCK
Gulf of Alaska
CATCH (1,000 t)

Year	Foreign	JVP	DAP	Total
1983	81.4	134.1	0.1	215.6
1984	99.3	207.1	0.3	306.7
1985	31.6	237.9	15.4	284.9
1986	0.1	62.6	21.3	84.0
1987	0.0	22.8	39.2	62.0
1988	0.0	0.2	55.8	56.0
1989	0.0	0.0	72.5	72.5
1990	0.0	0.0	77.8	77.8
1991	0.0	0.0	83.3	83.3
1992	0.0	0.0	83.2	83.2

Triennial bottom trawl surveys of the Gulf of Alaska and annual hydroacoustic surveys of Shelikof Strait during the spawning period (March) are conducted by the AFSC. Biomass estimates based on bottom trawl surveys show a stable biomass trend, whereas hydroacoustic surveys show a sharp decline. The 1990 biomass estimate from the summer bottom trawl survey was 766,948 t for the western and central regulatory areas combined. The 1990 hydroacoustic survey assessed the pollock biomass in Shelikof Strait and areas throughout the Gulf of Alaska from Prince William Sound to Davidson Bank. Most of the survey effort outside Shelikof Strait was concentrated between the 100 and 500 fathom contours. The 1990 hydroacoustic biomass estimate for Shelikof Strait was 381,594 t. The hydroacoustic estimate of the biomass outside of Shelikof Strait excluding Prince William Sound, was 102,271 t. A biomass estimate for Prince William Sound was not available. Hydroacoustic surveys of Shelikof Strait show an increase in spawning biomass from 382,397 t in 1991 to 580,000 t in 1992.

The entire pollock TAC in the Gulf of Alaska has been allocated to domestic fisheries since 1988. The 1991 and 1992 pollock quotas allocated for the western and central regions were 100,000 t and 84,000 t, respectively. In 1991, the TAC was divided into four equal quarterly allocations for each of the NPFMC regulatory areas.

Recent information on the age composition of the Gulf of Alaska pollock stock was available from the bottom trawl surveys, the spring hydroacoustic surveys of Shelikof Strait, and commercial fisheries. Age structures were collected from fish by port samplers and domestic observers. Age-composition estimates indicate that the 1984, 1985, and 1988 year classes were predominant in 1992.

The stock-synthesis model was used to assess the status of the Gulf of Alaska pollock stock in 1992. This model combines the analysis of catch, abundance, and age-composition data. The fisheries data set used in the analysis consisted of estimates of total catch biomass and the age composition of the catch aggregated over all seasons, nations, vessel classes, and statistical areas for years 1976-92. Fishery-independent data sets were incorporated into the stock-assessment procedure to help calibrate the resulting abundance estimates to the appropriate population level.

A simulation model was constructed to evaluate the long-term impact of various harvest strategies on Gulf of Alaska pollock. This model incorporated process error in our knowledge of the spawner-recruit relationship and measurement errors in our ability to assess the stock. An objective function was developed for the model that balanced increased yield against the risk of the spawner stock biomass falling below a threshold level set at 20% of the pristine spawner stock biomass. Two recruitment scenarios were evaluated. The long-term expected yield under a conservative recruitment scenario was 169,000 t.

Projections of Gulf of Alaska pollock biomass and yield have been made for fish age 3 and older for the period 1993-95. When fishing mortality is at the optimal level, and conservative assumptions regard-

ing recruitment were used, the 1993 yield would be 203,000 t for the western and central regulatory areas. The NPFMC set the TAC (111,000 t) and ABC (157,000 t) well below 203,000 t. An additional 3,400 t was allocated for the eastern regulatory area.

WALLEYE POLLOCK
Gulf of Alaska

Average catch (1977-92)	= 129,900 t
Long-term potential yield	= 169,000 t
Acceptable biological catch (1993)	= 160,000 t
Exploitable biomass (1993)	= 1,087,000 t
Harvesting strategy	= F = 0.15
Age/length at recruitment	= 3 yrs/30 cm
Age/length at 50% maturity	= 4-5 yrs/39-45 cm
Maximum age	= 18+ yrs
Abundance and trend	= Low and stable
Importance of recreational fishery	= Minor
Management	= GOA Groundfish FMP
Assessment Method	= Stock synthesis
Status of exploitation	= Below overfishing level

M = 0.30	F_{1993} = 0.15	$F_{overfishing}$ = 0.30
$F_{0.1}$ = 0.28	$F_{35\%}$ = 0.25	F_{msy} = 0.28

The overfishing level for pollock in the Gulf of Alaska was based on the $F_{30\%}$. The 1993 overfishing level was 286,000 t for the western and central areas combined. The overfishing harvest level for the eastern regulatory area was 7,880 t.

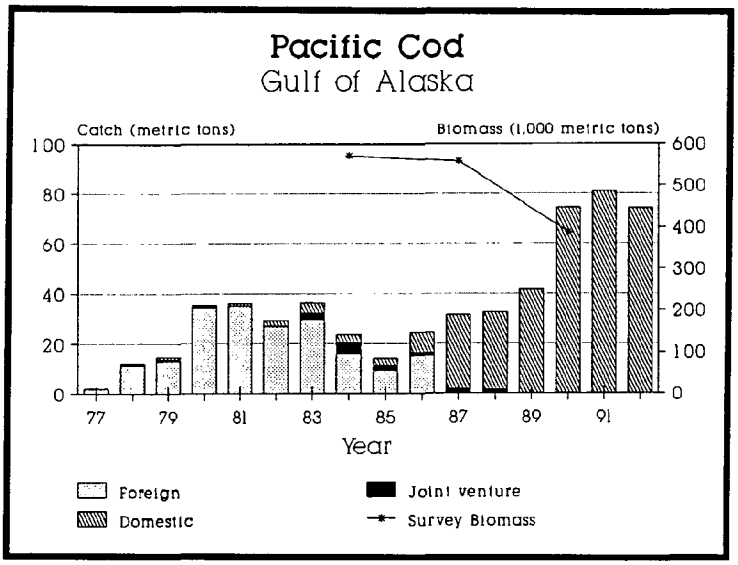
For further information

Hollowed, A. B., and B. A. Megrey. 1990. Walleye pollock. In Stock assessment and fishery evaluation document for the 1991 Gulf of Alaska groundfish fishery, p. 22-89. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

13. PACIFIC COD

By Harold H. Zenger, Jr.

Pacific cod (*Gadus macrocephalus*) occur on the continental shelf and upper slope along the coasts of the United States and Canada north of lat. 34°N and throughout the Gulf of Alaska, Aleutian Islands, and eastern Bering Sea to Norton Sound. Pacific cod tend to migrate long distances, resulting in an intermixing of the stocks between some regions. Thus the stocks from the Gulf of Alaska, Bering Sea, and Aleutian Islands regions are genetically indistinguishable. For management purposes, the stocks are managed as two seperate units according to their major areas of concentration - the Gulf of Alaska and Bering Sea-Aleutian Islands region.



Gulf of Alaska Pacific cod feed on a wide variety of crustaceans and fish and rarely reach 95 cm in length or 7 kg in weight. Maximum age of cod in this area is 15 years, but accurate ageing of the older fish is difficult. Sexual maturity is reached at about age 5. Spawning occurs during late winter and early spring.

The total Pacific cod catch in the Gulf of Alaska was 74,000 t in 1992, down 8% from 81,000 t in 1991. Trawlers caught 68% of the total 1991 cod landings; longline and pot fisheries landed 23% and 9%, respectively. Ex-vessel value of the catch was $38.4 million in 1992, down 8% from $41.7 million in 1991. Catches by recreational fisheries are insignificant. The catch reached a historical high proportion of groundfish landings in 1991 when it comprised 35% of all Gulf of Alaska groundfish landings. In 1992, however, the composition dropped to 28% of total groundfish landings.

During the phase of foreign fishing in the 1970s to the mid-1980s, the Pacific cod fishery was dominated by Japanese longline operations. The foreign catch peaked in 1981 at 35,000 t and ended in 1987. There was also a relatively small joint venture fishery operating at that time; it peaked in 1984 and ended after 1988.

PACIFIC COD
Gulf of Alaska

Average catch (1977-92)	= 34,450 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 56,700 t
Exploitable biomass (1993)	= 387,700 t
Harvesting strategy	= $F_{0.1}$
Age/length at recruitment	= 3 yrs/45 cm
Age/length at 50% maturity	= 5 yrs/60 cm
Maximum age	= 15+ years
Assessment Method	= Age-structured Model
Importance of recreational fishery	= Insignificant
Management	= GOA Groundfish FMP
Status of exploitation	= Fully exploited
Abundance and trend	= Moderate & declining

$M = 0.29$ $F_{0.1} = 0.18$ $F_{MSY} = F_{overfishing} = 0.18$
$F_{max} = 0.32$ $E_{1986-92\ average} = 0.096$

The assessement of the stocks is based mainly on trawl survey information. The surveys were conducted by the NMFS every third year, that is 1984, 1987, and 1990. Estimates of exploitable biomass (cod older than age 3) from these surveys were 570,000 t in 1984, 559,000 t in 1987, and 390,000 t in 1990. The higher biomass in the 1980s was due to the presence of the exceptionally large 1977 year class. Since then, year classes have been considerably weaker. With continued full fishing pressure and weaker recruitment in recent years, the resource is expected to continue to decline.

PACIFIC COD
Gulf of Alaska
COMMERCIAL CATCH (t)

Year	Foreign	JV	Domestic	Total
1983	29,777	2,416	4,198	36,401
1984	15,896	4,649	3,231	23,776
1985	9,086	2,266	2,954	14,306
1986	15,211	1,357	8,045	24,612
1987	0	1,978	29,454	31,432
1988	0	1,661	30,896	32,557
1989	0	0	41,676	41,676
1990	0	0	74,647	74,647
1991	0	0	80,974	80,974
1992	0	0	74,426	74,426

For further information

Zenger, H. H., and G. G. Thompson. 1992. Pacific cod In Stock assessment and fishery evaluation report for the 1993 Gulf of Alaska groundfish fishery. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

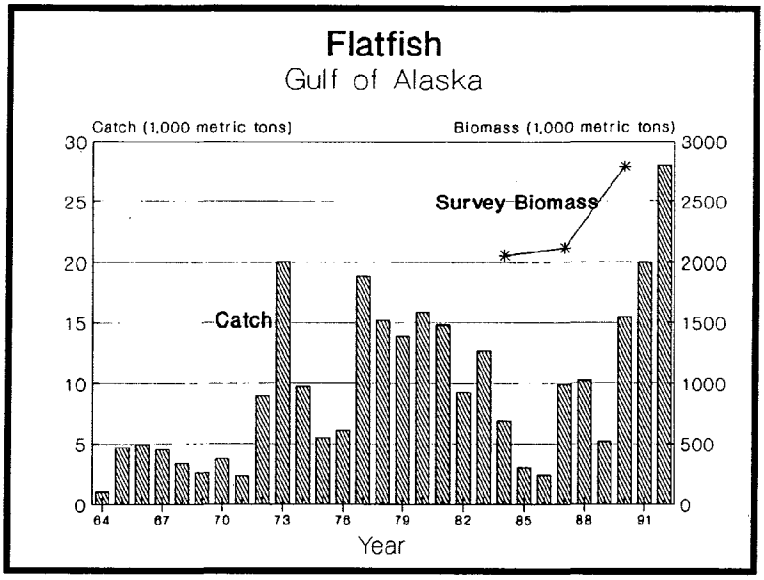
14. FLATFISH

By Thomas K. Wilderbuer and Eric S. Brown

Photo: AFSC

The flatfish species complex has been managed as a unit in the Gulf of Alaska and includes the major species of flatfish inhabiting the region. The major species, which comprise 98% of the current biomass, include: arrowtooth flounder (*Atherestes stomias*), flathead sole (*Hippoglossoides elassodon*), rock sole (*Pleuronectes bilineatus*), rex sole (*Errex zachirus*), Dover sole (*Microstomus pacificus*), yellowfin sole (*Pleuronectes asper*), and starry flounder (*Platichthys stellatus*). Gulf of Alaska flatfish are relatively slow-growing, long-lived species with similar biological characteristics depending on the size of the fish.

The NPFMC manages this resource and has divided the flatfish assemblage into four categories: "shallow-water" flatfish, "deep-water" flatfish, arrowtooth flounder, and flathead sole. These classifications



are necessary because of the very different halibut bycatch rates that occur in the directed fisheries targeting on shallow- and deep-water flatfish. Arrowtooth flounder, because of its present high abundance and low commercial value, was separated from the shallow- and deep-water groups and is managed under a separate TAC limit. Flathead sole are likewise assigned a separate limit because they overlap the depth distributions of the shallow- and deep-water groups.

FLATFISH
Gulf of Alaska
COMMERCIAL CATCH (t)

Year	Foreign	Joint venture	Domestic	Total
1983	9,530	2,692	439	12,661
1984	3,033	3,448	432	6,913
1985	170	2,447	461	3,078
1986	71	961	1,409	2,441
1987	0	7,207	2,718	9,925
1988	0	1,781	8,494	10,275
1989	0	0	5,167	5,167
1990	0	0	15,411	15,411
1991	0	0	20,068	20,068
1992	0	0	28,000	28,000

The Gulf of Alaska flatfish resource has been underexploited since at least 1964. From 1978 to 1981, the fishery caught about 15,000 t annually (all species), which was nearly all the result of foreign fishing in pursuit of non-flatfish species. By 1985, the catch decreased to less than one-half this amount as the fishery changed from foreign to joint venture operations. Catches increased to 10,300 t in 1988 and to 15,400 t in 1990 as joint venture fishing ceased and a near-shore domestic fishery developed at Kodiak Island. Catch levels increased to 20,000 t and 28,000 t for 1991 and 1992, respectively, but remained well below the TAC for both years.

Flatfish abundance information is available from three triennial bottom trawl surveys conducted in the Gulf of Alaska from 1984 to 1990. Generally, flatfish stocks have experienced a minimum of exploitation historically and are believed to be at abundant, stable levels. Size-composition information from the surveys indicate a continuing presence of young fish recruiting to the flatfish populations.

For further information

Wilderbuer, T. K., and E. S. Brown. 1992. Flatfish. In Stock assessment and fishery evaluation document for the 1993 Gulf of Alaska groundfish fishery, p. 106-124. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

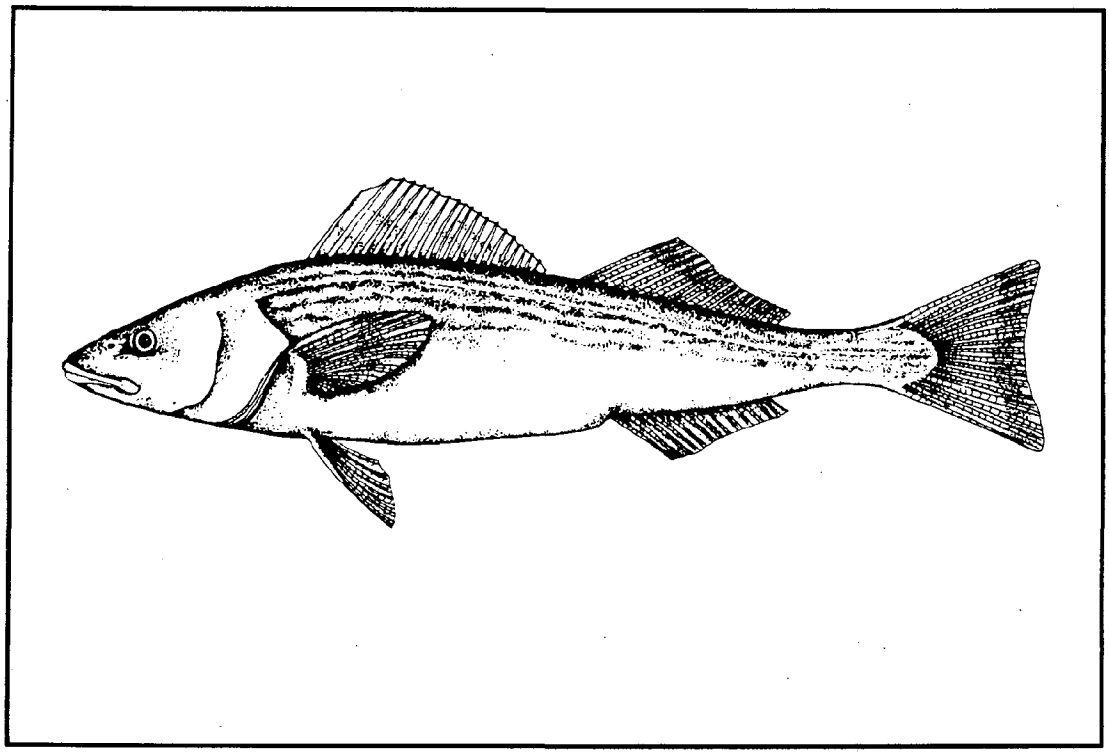
FLATFISH
Gulf of Alaska

Average catch (1977-92)	= 12,200 t
Long-term potential yield (MSY)	= 169,000 t
Acceptable biological catch (1992)	= 466,750 t
Exploitable biomass (1990 survey)	= 2,750,000 t
Harvesting strategy	= $F_{0.1}$
Age/length at recruitment	= 3-4 yrs/ ?
Age/length at 50% maturity	= 5 yrs/61 cm(females)
Maximum age	= 15+ years
Abundance and trend	= High and Stable
Importance of recreational fishery	= Minor
Management	= GOA Groundfish FMP
Assessment Method	= Trawl surveys
Status of exploitation	= Under-exploited

M = 0.2-0.22 $F_{0.1}$ = 0.17-0.20, F_{MSY} = 0.3-0.6
$F_{overfishing}$ = 0.24-0.30 $F_{1977-92}$ = very low

15. SABLEFISH

By Sanda A. Lowe and Jeffrey T. Fujioka



The distribution of sablefish (*Anoplopoma fimbria*) in North American waters ranges from the waters off northern Mexico through the Gulf of Alaska and along the Aleutian Island chain and edge of the continental slope in the eastern Bering Sea. Their range continues off the Siberia and Kamchatka coasts of Russia to the northeast coast of Japan. The resource is managed by discrete regions to distribute exploitation throughout its wide geographical range. There are three management areas in the northeast Pacific Ocean: the eastern Bering Sea, the Aleutian Islands region, and the Gulf of Alaska.

Eggs, larvae, and young-of-the-year juveniles are pelagic, but older juveniles and adults are demersal. They have a wide depth distribution--young juveniles are found in surface and near-shore waters down to depths of 150 m, older juveniles are found on or near the bottom in waters 100-200 m in depth, and adults are found in waters 150-1,200 m in depth. The bulk of the exploitable population occupies depths of 400-1,000 m. Sablefish mature at 4-6 years of age at sizes of 57-65 cm. Maximum age is 55+ years, and maximum size is about 100 cm. Sablefish spawn at depths of 300-750 m generally during the winter months. They are carnivores; adults feed primarily on fish and also nektonic and benthic invertebrates.

Sablefish of the Gulf of Alaska, eastern Bering Sea, and Aleutian Islands are considered one large stock. They are managed by the NPFMC. This resource has been harvested by U.S. and Canadian fishermen since the early 1900s, but catches were relatively low until the Japanese longline fleet began operations in the Eastern Bering Sea in 1958. The fishery rapidly expanded and catches peaked at 26,000 t in 1962. The Japanese fleet then expanded into the Aleutian Islands region and Gulf of Alaska. Catches in the Aleutian Islands region have historically remained at low levels. In the Gulf of Alaska, catches reached 37,500 t in 1972 and averaged about 28,000 t during 1973-76.

Evidence of declining stock abundance led to significant fishery restrictions from 1977 to 1985,

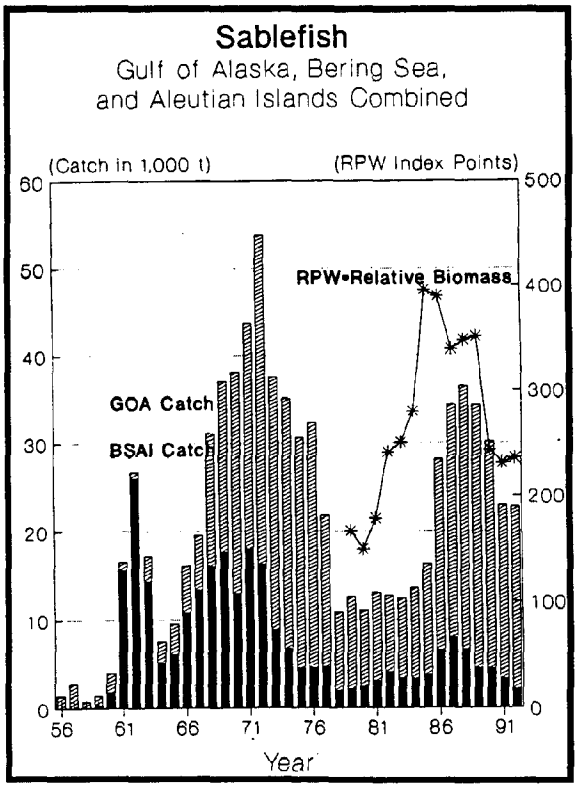
SABLEFISH
Eastern Bering Sea, Aleutian Islands and Gulf of Alaska
COMMERCIAL CATCH (1,000 t)

Category	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Eastern Bering Sea										
Foreign	2.6	1.2	0.2	0.1	0.0	--	--	--	--	--
Joint venture	0.0	0.1	0.0	0.3	0.1	0.0	0.0	--	--	--
Domestic	0.1	1.0	2.1	3.1	4.1	3.2	1.2	2.3	1.2	0.6
Subtotal	2.7	2.3	2.3	3.5	4.2	3.2	1.2	2.3	1.2	0.6
Aleutian Islands										
Foreign	0.6	0.7	0.1	--	--	--	--	--	--	--
Joint venture	0.1	0.3	0.1	0.1	0.1	0.0	--	--	--	--
Domestic	--	0.0	1.3	2.9	3.8	3.4	3.2	2.2	2.1	1.4
Subtotal	0.7	1.0	1.5	3.0	3.9	3.4	3.2	2.2	2.1	1.4
Gulf of Alaska										
Foreign	5.0	1.1	0.0	0.0	--	--	--	--	--	--
Joint venture	0.0	0.5	0.2	0.0	0.2	0.0	--	--	--	--
Domestic	3.8	8.6	12.2	21.6	26.1	29.9	29.8	25.7	19.6	20.8
Subtotal	8.8	10.2	12.4	21.6	26.3	29.9	29.8	25.7	19.6	20.8
Total	12.2	13.5	16.2	28.1	34.4	36.5	34.2	30.2	22.9	22.8

and total catches were reduced substantially. Total catches increased steadily after 1983, reaching a peak of 36,500 t in 1988 with an ex-vessel value of $78.5 million. Total sablefish commercial catch in the eastern Bering Sea/Aleutian Islands and Gulf of Alaska in 1992 was 22,700 t valued at $51 million (ex-vessel value). This species is of minor recreational importance.

Stock-reduction analysis revealed declining stock sizes through 1978. Estimates of exploitable biomass after 1979 were determined from survey data by scaling indices of biomass from annual longline surveys to absolute biomass based on comparisons of longline and bottom trawl survey catch rates. The surveys indicted that stock biomass increased after 1980 and peaked in 1985 at nearly 400,000 t. Lower exploitation rates and a strong 1977 year class, which recruited in 1982, led to this improved stock condition. After 1986, stock size has been relatively stable but has shown a slight decline. Although stock size may be declining, there is no evidence that it is being overfished. The decline is attributed to the lack of significant recruitment in recent years. The stock is at a high level and considered to be in good condition.

In the past, a constant $F_{0.1}$ fishing rate policy was applied to sablefish. Recent simulation studies have



SABLEFISH
Bering Sea, Gulf of Alaska, and Aleutian Islands

Average catch (1977-92)	= 20,900 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 25,000 t
Exploitable biomass (1993)	= 227,400 t
Harvesting strategy	= $F_{35\%} * (B_{93} / B_{35\%})$
Age/length at recruitment	= 5 yrs/60 cm
Age/length at 50% maturity	= 4-6 yrs/57-65 cm
Maximum age	= 55+ yrs
Abundance and trend	= High and declining
Importance of recreational fishery	= Minor
Management	= GOA and BSAI Groundfish FMPs
Assessment Method	= Stock-reduction analysis and yield-per-recruit
Status of exploitation	= Fully exploited

M = 0.10 $F_{0.1}$ = 0.13 F_{MSY} = Unknown
$F_{overfishing}$ = 0.16 $F_{1979-92\ average}$ = 0.09

been conducted to examine harvest strategies that reduce the risk of overfishing. One of the strategies that reduces this risk, in comparison to a constant fishing rate strategy, is a variable rate that decreases proportionately as biomass decreases below a desirable reference level. Such a policy should reduce risk without appreciably reducing average catch levels. For 1993, sablefish were harvested under an $F_{35\%}$ strategy adjusted by the ratio of current biomass to $B_{35\%}$ or ($B_{93}/B_{35\%}$). The resource is considered fully utilized.

For further information

Fujioka, J.T. 1992. Sablefish. In Stock assessment and fishery evaluation report for the 1993 Gulf of Alaska groundfish fishery. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, AK 99510.

Lowe, S.A. 1992. Sablefish. In Stock assessment and fishery evaluation document for the 1993 Gulf of Alaska groundfish fishery. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

Sigler, M.F., and J.T. Fujioka. 1992. Harvest policies for sablefish in the Gulf of Alaska. Proceedings of the Symposium on Management Strategies for Exploited Fish Populations. Lowell Wakefield Fisheries Symposium, Oct. 21-24, 1992. Anchorage, Alaska.

16. SLOPE ROCKFISH

By David M. Clausen and Jonathan Heifetz

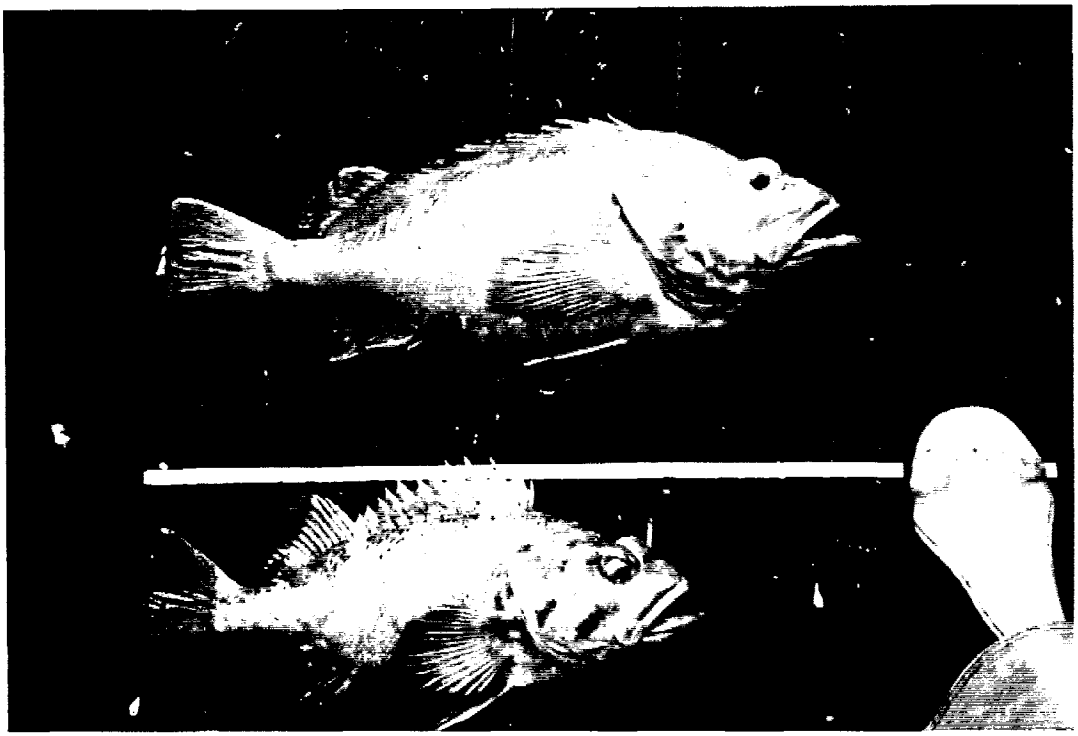
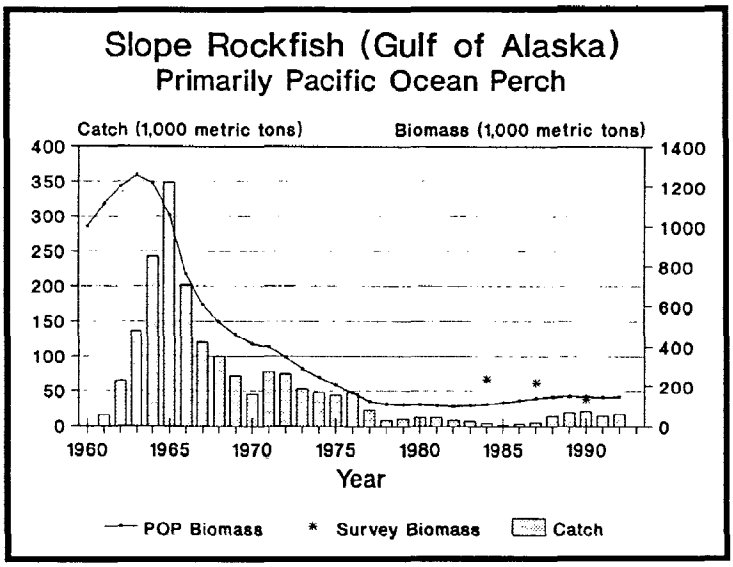


Photo: AFSC

The NPFMC presently classifies 20 Gulf of Alaska rockfish species (genus *Sebastes*) into the slope rockfish assemblage. Slope rockfish are defined as those species of *Sebastes* that as adults inhabit offshore waters of the outer continental shelf and continental slope, generally in depths greater than 150-200 m. Trawl surveys in the Gulf of Alaska indicate that eight species of slope rockfish together comprise more than 99% of the estimated total biomass for the assemblage: Pacific ocean perch (*Sebastes alutus*), northern rockfish (*S. polyspinis*), rougheye rockfish (*S. aleutianus*), sharpchin rockfish (*S. zacentrus*), redstripe rockfish (*S. proriger*), harlequin rockfish (*S. variegatus*), silvergray rockfish (*S. brevespinis*), and shortraker rockfish (*S. borealis*). The remaining 12 species appear to have a relatively sparse distribution in the Gulf of Alaska.

Of the eight major species of slope rockfish, Pacific ocean perch has historically been the most abundant and provided most of the commercial



catch. Almost all research on slope rockfish has concentrated on Pacific ocean perch; little biological or assessment information is available for the other species. Consequently, this synopsis will deal mostly with Pacific ocean perch.

SLOPE ROCKFISH
(Primarily Pacific ocean perch)
Gulf of Alaska
COMMERCIAL CATCH (t)

Year	Foreign	Joint Venture	Domestic	Total
1983	5,415	1,975	15	7,405
1984	2,599	1,734	119	4,452
1985	8	254	825	1,087
1986	0	37	2,944	2,981
1987	0	112	4,869	4,981
1988	0	8	13,771	13,779
1989	0	0	19,002	19,002
1990	0	0	21,114	21,114
1991	0	0	13,994	13,994
1992	0	0	17,300	17,300

The Gulf of Alaska appears to be the center of abundance for Pacific ocean perch, although the species ranges south to the coastal waters of southern California, north to the Bering Sea and west to the Pacific coast of Russia. The species is slow-growing and long-lived; a maximum age of 78 years has been reported from the Gulf of Alaska. Because of this slow growth and longevity, the estimated rate of instantaneous natural mortality (0.05) is quite low compared with most other groundfish species. This species begins to recruit to the fishery at about age 5 and is fully recruited by age 16, corresponding to fork lengths of 27 cm and 40 cm, respectively. The maximum length recorded is 51 cm. The sparse information on other slope rockfish species indicates that they are also slow-growing and long-lived.

Commercial fishing for Pacific ocean perch in the Gulf of Alaska began in the early 1960s by Soviet and Japanese trawlers. Catches peaked in 1965 at 350,000 t. The stock could not sustain this heavy level of exploitation, and catches declined precipitously in the late 1960s. This decline continued in the 1970s and early 1980s. When the foreign trawl fishery was terminated in 1984, the catch of Pacific ocean perch totaled only 4,500 t.

A significant domestic fishery for slope rockfish developed in 1985, and catches increased annually until 1990 when the total was 21,114 t. In 1991 and 1992, catches diminished somewhat as a result of more restrictive management policies. The gross wholesale value of the 1992 trawl catch is estimated at $22 million. Over the years of this domestic fishery, Pacific ocean perch has apparently been the major species caught. Recent fisheries, however, also target on shortraker and rougheye rockfish, two larger sized species that inhabit deeper waters (greater than 300 m) of the continental slope, and on northern rockfish, which is found in shallower water on the outer continental shelf.

The Pacific ocean perch stock was severely depressed when the Japanese fishery ended in 1984. The stock apparently never rebounded from the overfishing that occurred in the 1960s. More recent assessments of Pacific ocean perch, based primarily on trawl surveys in 1984, 1987, and 1990, showed that the stock was still low. There was, however, some evidence of successful recruitment, especially from relatively strong 1976 and 1980 year classes. The current stock condition is uncertain, although it is still thought to be very depressed compared to its former (pre-1960) abundance. Recently, a stock synthesis model has been applied to Pacific ocean perch that incorporates data from a variety of sources, including past age compositions, biomass estimates from the three trawl surveys, and CPUE data from the commercial fishery. Based on this model, the current best estimate of exploitable biomass for Pacific ocean perch is 153,600 t.

In 1991, the NPFMC divided the slope assemblage into three management subgroups: Pacific ocean perch, shortraker-rougheye, and "other slope rockfish." The reason for this division was to prevent possible selective overharvest of the more highly valued species in the assemblage. In 1993, the NPFMC further divided "other slope rockfish" by separating out northern rockfish as its own management subgroup. Separate ABCs and TACs are now assigned to each of the four subgroups. Pacific ocean perch is currently managed under an $F_{35\%}$

PACIFIC OCEAN PERCH
(Dominant Slope Rockfish Species)
Gulf of Alaska

Average catch (1977-92)	= 11,280 t (includes other species of slope rockfish)
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 5,560 t (21,580 t for assemblage)
Exploitable biomass (1993)	= 153,600 t (457,036 t for assemblage)
Fishing strategy	= $F = F_{35\%}$; F = M for other species
Age/length at recruitment	= 5-16 years/27-40 cm
Age/Length at 50% maturity	= Males: 5.0-6.2 years/27.5-30.5 cm Females: 5.4-10.0 years/28.5-36.3 cm
Maximum age	= 78 years
Abundance and trend	= Low and uncertain.
Importance of Recreational Fishery	= Minor
Management	= GOA Groundfish FMP
Assessment level	= Yield-per-recruit/stock synthesis
Status of exploitation	= Fully utilized

M = 0.05 $F_{0.1}$ = 0.08 F_{MSY} = Unknown
$F_{overfishing}$ = 0.08 $F_{1977-92\ average}$ = 0.07

harvesting strategy, whereas shortraker-rougheye, northern rockfish, and "other slope rockfish" are managed using an F = M strategy.

For further information

Heifetz, J., and D. M. Clausen. 1992. Slope rockfish. In Stock assessment and fishery evaluation report for the 1993 Gulf of Alaska groundfish fishery. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

Heifetz, J., and J. N. Ianelli. 1992. Stock assessment of Pacific ocean perch in the Gulf of Alaska based on the stock synthesis model. In Stock assessment and fishery evaluation report for the 1993 Gulf of Alaska groundfish fishery, Appendix IV. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

17. PELAGIC SHELF ROCKFISH

By David M. Clausen and Jonathan Heifetz

DUSKY ROCKFISH
(Dominant Pelagic Shelf Rockfish Species)
Gulf of Alaska

Average catch (1988-92)	= 2,050 t (includes other species of pelagic shelf rockfish)
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 6,740 t
Exploitable biomass (1993)	= 74,900 t
Harvesting strategy	= F = M
Age/length at recruitment	= Unknown/unknown
Age/length at 50% maturity	= Unknown/unknown
Maximum age	= 49 years
Abundance and trend	= Both unknown
Importance of recreational fishery	= Minor
Management	= GOA Groundfish FMP
Assessment Method	= Trawl surveys
Status of exploitation	= Under-exploited

M = 0.09 $F_{0.1}$ = Unknown F_{MSY} = Unknown
$F_{overfishing}$ = Unknown $F_{1979-92\ average}$ = Unknown

The pelagic shelf rockfish management assemblage in the Gulf of Alaska includes five species of *Sebastes*. These fish typically inhabit waters of the continental shelf of the Gulf of Alaska and exhibit a midwater schooling behavior. At times, however, some of the fish are found near the bottom where they can be captured using bottom trawls. Dusky rockfish (*Sebastes ciliatus*) is the most abundant species in the assemblage. Trawl surveys have shown this species to comprise 92-99% of the total biomass for the group. Most of this synopsis, therefore, will deal with dusky rockfish.

There is relatively little biological information on dusky rockfish. The species ranges from the waters off northern British Columbia to the Bering Sea and is apparently most abundant in the Gulf of Alaska. Maximum reported age is 49 years, but there are no data on age or size of recruitment. A natural mortality rate (M) has been recently estimated at 0.09, which indicates that dusky rockfish is relatively fast-growing compared to most other rockfish species in Alaska. Dusky rockfish can attain a maximum length of 53 cm.

Catch statistics for pelagic shelf rockfish in the Gulf of Alaska are only available beginning in 1988 when this management group was created. In general, catches have increased during this time period. Nevertheless, they have remained much less than the assigned TAC, which indicates the assemblage has been underutilized. Most of the catch has been dusky rockfish taken by bottom trawls. In 1991 and 1992, however, a jig fishery for black rockfish (*Sebastes melanops*) developed in the central Gulf of Alaska, and this fishery caught 500 t each year.

The only stock-assessment information for pelagic shelf rockfish comes from three bottom trawl surveys in the Gulf of Alaska. Estimated exploitable biomass for dusky rockfish in these surveys showed a wide variation, from 37,313 t in 1984, increasing to 163,188 t in 1987, and falling to 24,141 t in 1990. These large fluctuations do not appear to be reasonable when one considers the low natural mortality rate for dusky rockfish and the relatively small commercial catches. One hypothesis is that some portion of the population may have moved off bottom in 1984 and 1990 and hence, was not captured in the survey. Thus, present stock condition of pelagic shelf rockfish is uncertain, although dusky rockfish are thought to be more abundant now than they were in the 1960s and 1970s.

Pelagic shelf rockfish are presently managed using an F = M strategy, in which ABC is determined by applying the natural mortality rate for dusky rockfish (0.09) to the exploitable biomass of

the assemblage. Due to the uncertainty of the trawl survey results, the average of the exploitable biomass estimates from the three surveys (74,889 t) is used for these computations.

For further information

Clausen, D. M., and J. Heifetz. 1992. Pelagic shelf rockfish. In Stock assessment and fishery evaluation report for the 1993 Gulf of Alaska groundfish fishery. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

DUSKY ROCKFISH
(Dominant Pelagic Shelf Rockfish Species)
Gulf of Alaska
COMMERCIAL CATCH (t)

	Western	Central	Eastern	Total
1988	400	518	168	1,086
1989	113	888	737	1,738
1990	165	955	527	1,647
1991	215	1191	937	2,342
1992	73	2387	980	3,440

18.DEMERSAL SHELF ROCKFISH

By Victoria M. O'Connell and Jeffrey T. Fujioka

The demersal shelf rockfish assemblage includes eight species of rockfish that are found most commonly near shore at depths less than 200 m off Southeast Alaska. The two most important species in the assemblage, yelloweye rockfish (*Sebastes ruberrimus*) and the quillback rockfish (*S. maliger*) are distributed from the waters off California to Prince William Sound. The demersal shelf rockfish are managed by the NPFMC as a distinct assemblage only off southeast Alaska, where they are targeted by a small shore-based fishery. Management in the EEZ is done jointly by the NPFMC with the ADF&G.

Species in the demersal shelf rockfish assemblage are ovoviviparous, with the majority of fish extruding larvae in late winter and spring. Yelloweye rockfish extrude larvae over an extended time period, with the peak period occurring in April and May. Like other rockfish, the demersal shelf rockfish are considered to be slow-growing and long-lived with a low natural mortality rate. The ages of yelloweye rockfish caught by the fishery range from 13 to 114 years, with first modes occurring around 35 years of age in lightly exploited areas and around 18-20 years in exploited areas.

Demersal shelf rockfish have been landed incidental to other fisheries in Southeast Alaska since the turn of the century. In 1979, a small shore-based rockfish fishery began, targeting primarily on this nearshore bottom-dwelling complex. The directed harvest of demersal shelf rockfish peaked in 1987 at 726 t. Catches declined in 1988 to 505 t and further to 310 t in 1989. Much of the decline in harvest can be attributed to closures of the directed fishery for conservation. The TAC was reduced from 660 t in 1988 to 420 t in 1989 and then increased to 470 t in 1990 to allow for an increase in bycatch. In 1991, the ABC was constrained to 445 t, the mean catch since 1982 to 1989, as required by the NPFMC overfishing definition.

In 1992 the Southeast Outside district, defined for demersal shelf rockfish (DSR) management, was expanded 2° west, to long. 140° W. Since 1992 biomass has been derived from a combination of density of yelloweye rockfish/km^2 estimates from submersible line transects, areal estimates of available "rocky" habitat, and mean weight data from the commercial fishery. In 1993, the ABC and TAC (800 t) were set by multiplying the lower end of the 90% confidence interval for biomass (40,049 t) by the natural mortality rate (0.02).

Yelloweye rockfish, the primary target species, accounted for over 85% of the landed weight in the 1992 DSR longline fishery. Demersal shelf rockfish

DEMERSAL SHELF ROCKFISH COMPLEX
Gulf of Alaska

Average catch (1982-92)	= 450 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 800 t
Exploitable biomass (1993)	= 40,000 t
Harvesting strategy	= Accommodate directed and bycatch fishery needs
Age/length at recruitment	= 20 years/51-54 cm
Age/length at 50% maturity	= 20-25 years/47-49 cm
Maximum age	= 114+ years
Abundance and trend	= Unknown and declining
Importance of recreational fishery	= Minor
Management	= GOA Groundfish FMP and State of Alaska
Assessment Method	= Yield-per-recruit with line transect density
Status of exploitation	= Local depletions

$M = 0.02$ $F_{0.1} = 0.03$ F_{MSY} = Unknown
$F_{overfishing} = 0.04$ $F_{1979-89\ average}$ = Unknown

(Values for age, length, M and F are for Sebastes ruberrimus)

are also taken as bycatch in the longline fishery for halibut and in trawl fisheries for "slope rockfish." While the directed fishery harvest has been declining since 1987, the reported bycatch has increased dramatically. The recreational fishery is of minor significance at this time; most fish are taken incidentally and there is only occasional targeting on yelloweye and quillback rockfish.

DEMERSAL SHELF ROCKFISH
Gulf of Alaska
COMMERCIAL CATCH (t)

Category	1984	1985	1986	1987	1988	1989	1990	1991	1992
Directed	543	388	449	726	505	310	199	386	352
Incidental	20	100	41	47	53	103	128	119	215
Total	563	488	491	773	558	413	327	505	567

In past years, shifts in effort to grounds farther from the port of landing have been noted in all five Gulf of Alaska management areas. Considering that most Southeast Alaskan processors limit trip time to 4 days and the additional cost associated with fishing farther from port, the progressive expansion to more distant fishing grounds is considered to be a strong indication that abundance has declined near the major ports.

For further information

O'Connell, V. M. 1987. Reproductive seasons for some *Sebastes* species in Southeastern Alaska. Alaska Dep. Fish and Game Info. Leaflet No. 263. Juneau, AK.

O'Connell, V. M., and F. C. Funk. 1987. Age and growth of yelloweye rockfish (*Sebastes ruberrimus*) landed in Southeastern Alaska. In B. R. Melteff (ed.), Proceedings of the International Rockfish Symposium. p. 171-185. Alaska Sea Grant Report No. 87-2.

O'Connell, V. M., D.W. Carlile, and B. E. Bracken. 1992. Demersal shelf rockfish. In Stock assessment and fishery evaluation report for the 1993 Gulf of Alaska groundfish fishery. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

O'Connell, V.M., and D.W. Carlile. 1993. Habitat specific density of adult yelloweye rockfish in the eastern Gulf of Alaska. Fish. Bull., U.S. 91(2): 304-309.

19. THORNYHEADS

By Loh-Lee Low

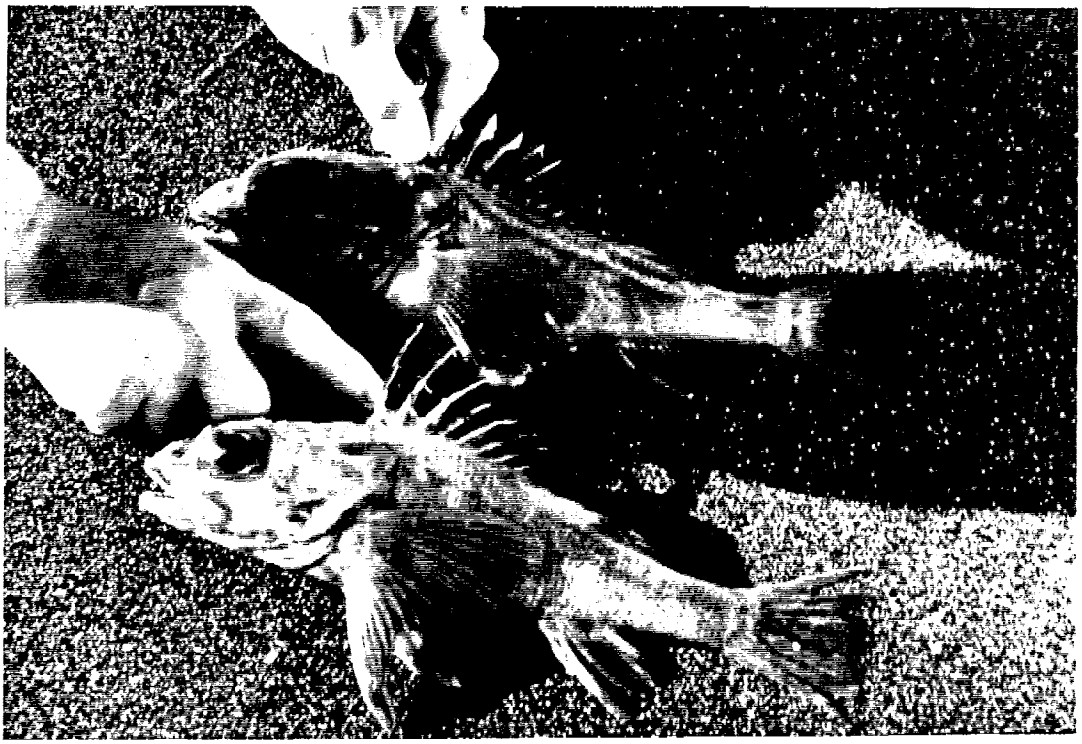


Photo: AFSC

Thornyheads of the northeastern Pacific Ocean are comprised of two species, the shortspine thornyhead (*Sebastolobus alascanus*) and the longspine thornyhead (*S. altivelis*). The longspine thornyhead is rare in the Gulf of Alaska. Shortspine thornyheads occur demersally along the continental slope from 100 to 1,500 m in depth from Baja California to the Bering Sea. In the Gulf of Alaska, greatest concentrations are found at 300 - 700 m.

Thornyheads are slow-growing and long-lived with maximum age in excess of 50 years and maximum size greater than 50 cm and 2 kg. Thornyheads are caught by trawl and longline gear with the bulk of the fishery occurring in late winter or early spring through the summer.

Thornyheads are managed under the Gulf of Alaska groundfish FMP. Catches were mainly made by foreign fisheries until the early 1980s and were less than 1,400 t. The catch decreased markedly in 1984 and 1985 because of restricted foreign fishing in the Gulf. In 1985, the U.S. catch surpassed the foreign catch for the first time as U.S. fisheries expanded. The catch peaked in 1989 at 3,079 t. Catches since 1991 have been close to the established quota. In 1992, the ex-vessel value of the catch was $1.7 million.

Based on trawl survey data, abundance of

SHORTSPINE THORNYHEADS
Gulf of Alaska
COMMERCIAL CATCH (t)

Year	Foreign	Joint Venture	Domestic	Total
1983	716	13	0	729
1984	165	19	24	208
1985	4	9	69	82
1986	0	1	713	714
1987	0	20	1,943	1,963
1988	0	8	2,787	2,787
1989	0	0	3,079	3,079
1990	0	0	1,646	1,646
1991	0	0	1,217	1,217
1992	0	0	1,653	1,653

thornyheads in the Gulf of Alaska has declined sharply from 123,000 t in 1984 to 99,000 t in 1987, and to 26,000 t in 1990. Since abundance of thornyheads was first measured in 1984, landings have never exceeded 6.5% of biomass, while from 1984 to 1988, landings did not exceed 4%.

The MSY for thornyheads cannot be estimated. Acceptable biological catches, however, were estimated from survey biomass data at 1,798 t for 1992 and 1,180 t for 1993.

SHORTSPINE THORNYHEADS
Gulf of Alaska

Average catch (1981-92)	= 1,350 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 1,180 t
Exploitable biomass (1993)	= 26,200 t
Harvesting strategy	= $F_{35\%}$
Age/length at recruitment	= 16 yrs/25 cm
Maximum age	= 62+ yrs
Abundance and trend	= Low and declining
Importance of recreational fishery	= Minor
Management	= GOA Groundfish FMP
Assessment Method	= Yield-per-recruit
Status of exploitation	= Fully exploited

$M = 0.05$ $F_{0.1} = 0.07$ $F_{MSY} = 0.05$ $F_{1993} = 0.045$
$F_{overfishing} = 0.055$ $F_{average} = 0.03$

For further information

Dawson, P. K. 1992. Thornyheads. In Stock assessment and fishery evaluation report for the 1993 Gulf of Alaska groundfish fishery. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

20. PACIFIC HALIBUT

By Patrick J. Sullivan

The Pacific halibut, *Hippoglossus stenolepis*, is the largest member of the flounder family Pleuronectidae with males weighing up to 54 kg and females weighing up to 230 kg. Commercially caught Pacific halibut generally range in age from 8 to 17 years, although the oldest recorded age for a Pacific halibut is 42 years. Males become sexually mature between the ages of 7 and 13 years, while females mature at 9 to 15 years. During the spring and summer feeding periods, Pacific halibut are found on the continental shelf along the Pacific coast of North America, with the bulk of the population residing in the Gulf of Alaska. In the winter, adult Pacific halibut migrate to spawning grounds along the continental slope.

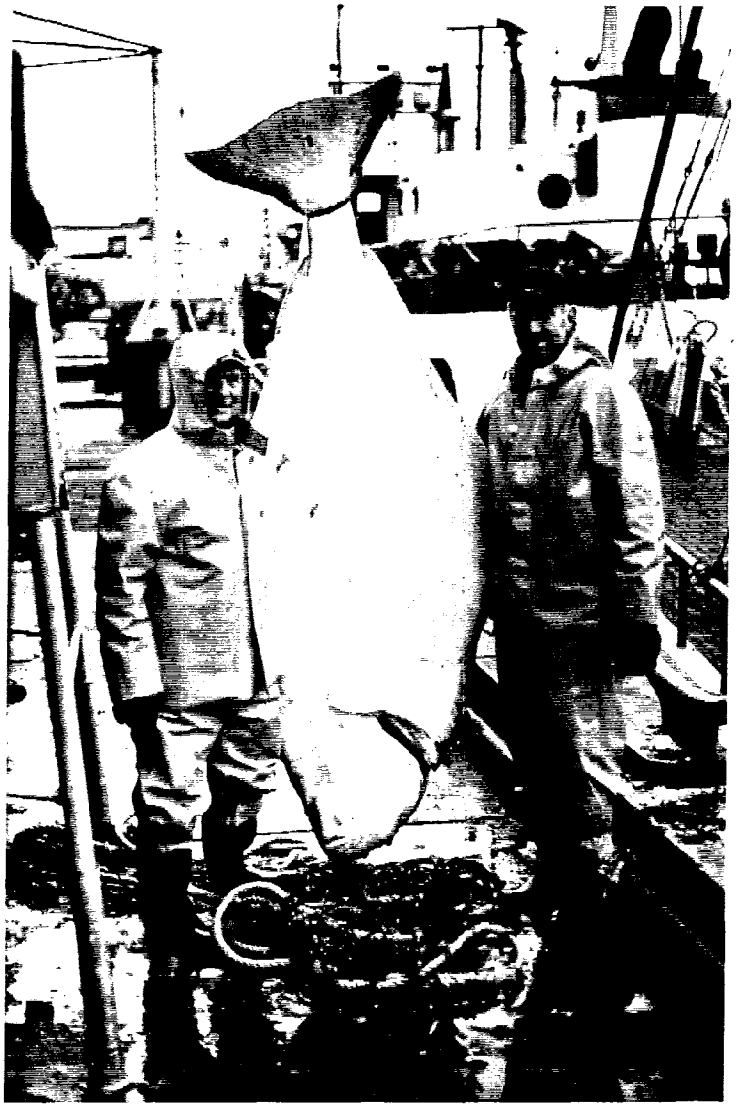


Photo: IPHC

The Pacific halibut population has supported a directed longline commercial fishery since the late 1800s. Longliners use gear consisting of groundline, gangions, and hooks. A skate of gear is commonly made up of 1,800 ft of groundline, with gangions attached every 18 ft. The J-shaped hook traditionally attached to each gangion has gradually been replaced by a more efficient circle hook. Most of the fleet now uses snaps to attach the gangion to the groundline, although some fishermen continue to use "fixed" gear with the gangions permanently attached.

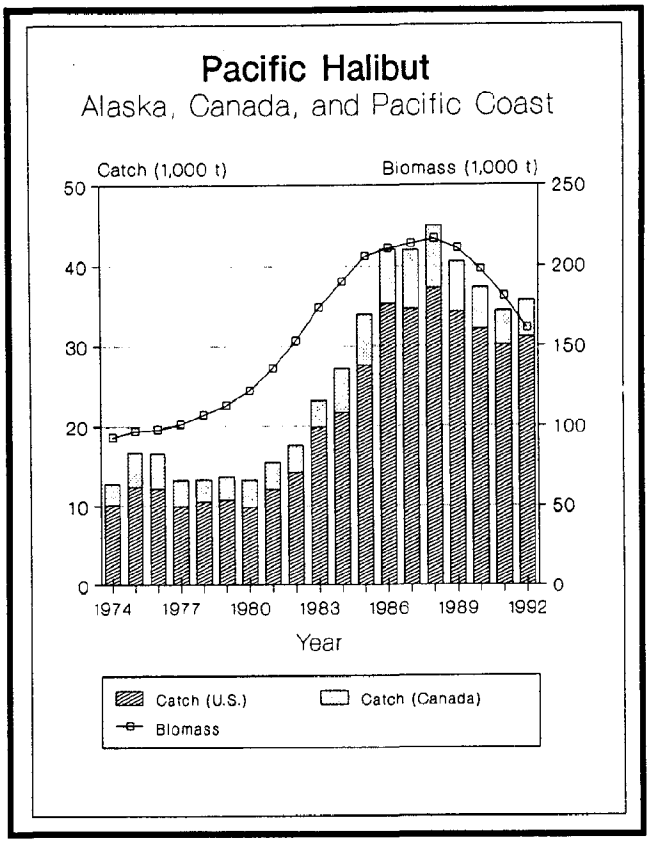
In 1923, a Convention between Canada and the United States established the International Pacific Halibut Commission, originally called the International Fisheries Commission, to manage the Pacific halibut resource. The Commission directs research and establishes management regulations to preserve and develop the Pacific halibut fishery. The fishery is regulated by controlling catch through time and area closures in U.S. waters and by individual quota management in Canada. In the United States, over 6,300 vessels were commercially licensed to operate in 1992, while in Canada, where an Individual Vessel Quota System was implemented in 1991,

435 vessels were eligible to fish.

In 1992, nearly 36,000 t of Pacific halibut were landed by the commercial longline fishery: 31,000 t in the United States and 5,000 t in Canada, with a total ex-vessel value of $66 million (U.S.). The 1992 harvest reflects a 3% increase in yield from the 34,000 t of Pacific halibut commercially landed in 1991. Other removals of Pacific halibut in 1992 include 4,300 t landed by recreational fisheries, 1,500 t wastage due to gear loss and discard, and 9,500 t lost to mortality by fisheries not specifically directed at halibut.

The stock is assessed on an annual basis using an area by area catch-at-age analysis. The exploitable biomass was estimated to peak at 217,000 t in 1987 and 1988 after a period of stock rebuilding. The population has declined since that time at an average rate of 7% per year. Strong 1977 and 1979 year classes contributed to this build-up of the stock with weaker year classes subsequently contributing to the decline.

Research on optimal exploitation strategies indicate that a constant 30% harvest rate on the exploitable portion of the stock will maximize the yield of Pacific halibut with minimum risk to the population. After accounting for other removals this translates, as a management objective, to a commercial harvest rate of 0.20 on the fully exploitable stock with the instantaneous fishing mortality rate ranging from 0.05 to 0.25 for fish larger than the 82 cm size limit. Directed commercial fishing mortality rates on legal-sized Pacific halibut were relatively constant during the period of stock increase averaging 0.20 during the years 1974 through 1985. More recently the fishing mortality rate has increased to



PACIFIC HALIBUT
Alaska and the Pacific Coast

Average catch (1977-92)	= 28,520 t
Long-term potential yield (MSY)	= 30,000-36,000 t
Exploitable biomass (1992)	= 161,000 t
Abundance and trend	= High and declining
Status of exploitation	= Fully exploited
Importance of recreational fishery	= Major
Management	= International Pacific Halibut Commission
Age/length at 50% maturity	= Male 8 yrs/72 cm Female 12 yrs/122 cm
Assessment Method	= Age structured

M = 0.20 $F_{0.1}$ = 0.16 F_{MSY} = 0.22 F_{1992} = 0.33

an average of 0.32. The change in the average rate results from a combination of factors including stock decline and an increase in fleet participation in the fishery.

PACIFIC HALIBUT
Alaska and the Pacific Coast
CATCH (1,000 t)

YEAR	RECREATIONAL	COMMERCIAL		TOTAL
		U.S.	Canada	
1983	1.0	19.9	3.3	24.2
1984	1.1	21.7	5.5	28.3
1985	1.6	27.6	6.3	35.5
1986	2.0	35.3	6.8	44.1
1987	2.2	34.6	7.4	44.2
1988	3.1	37.2	7.8	48.1
1989	3.3	34.2	6.3	43.8
1990	3.6	32.1	5.2	40.9
1991	4.2	30.1	4.3	38.6
1992	4.0	31.1	4.6	39.7

For further information

International Pacific Halibut Commission. 1987. The Pacific halibut: Biology, fishery, and management. IPHC Tech. Rep. 22., 59 p. Int. Pacific Halibut Comm., P.O. Box 95009, Seattle, WA 98145-2009.

International Pacific Halibut Commission. 1990. Annual Report, 1990. 40 p. Int. Pacific Halibut Comm., P.O. Box 95009, Seattle, WA 98145-2009.

21. PACIFIC HERRING

By Vidar G. Wespestad

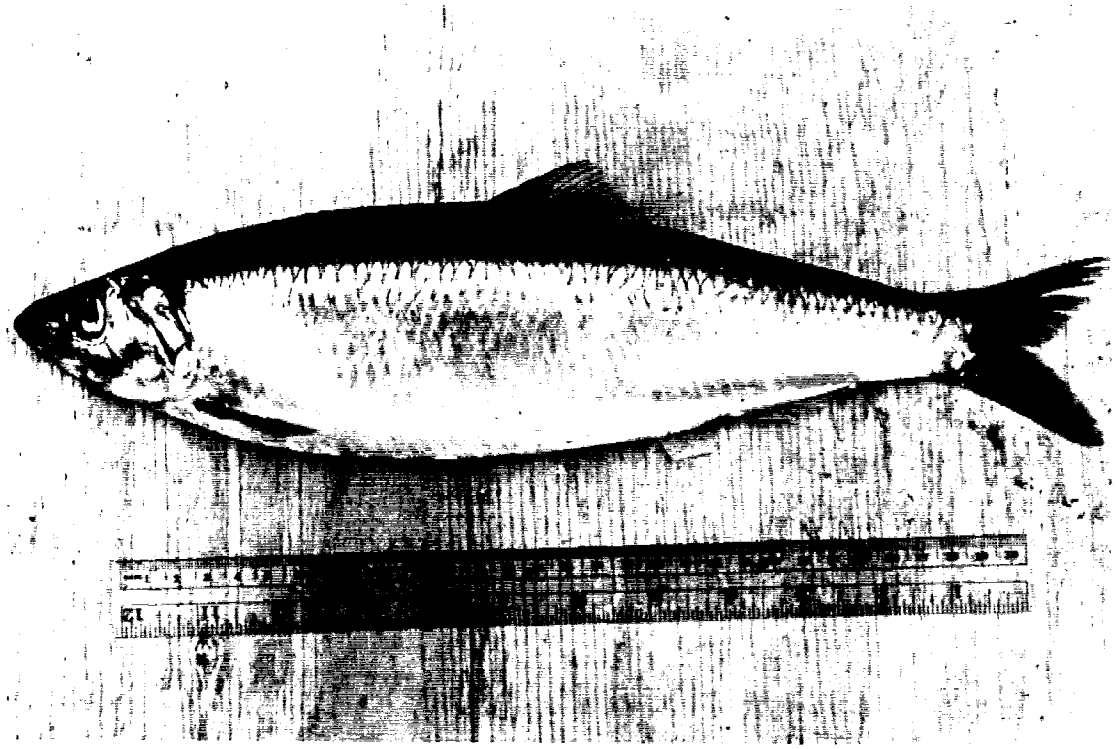


Photo: AFSC

The Pacific herring (*Clupea pallasi*) occurs throughout the Gulf of Alaska, Bering and Chukchi Seas and have been reported to occur in the Arctic Ocean east to the Mackenzie River Delta. Major concentrations of herring in the Gulf of Alaska occur in the waters off Southeast Alaska, Prince William Sound, and Kodiak Island-Cook Inlet. In the Bering Sea, major centers of abundance are northern Bristol Bay and Norton Sound. In the Chukchi Sea and the Arctic Ocean, abundance is low and commercial concentrations of herring have been located only in Kotzebue Sound.

Herring have been exploited in Alaska since the late 1800s. Early fisheries produced salted and dried herring. In the 1920s, herring began to be utilized in reduction fisheries in which oil and fish meal were the principal products. The reduction fisheries continued into the mid-1960s when high production of lower cost Peruvian anchovy oil and meal made it unprofitable to operate reduction plants in Alaska. In the early 1970s, herring fisheries shifted to harvesting roe-bearing herring. These fisheries occur during the herring spawning period, which runs from late March in Southeast Alaska to late June in Norton Sound. A small amount of herring is also harvested for sale or use as bait. The principal bait fisheries occur in winter in southeastern Alaska and in summer in the Bering Sea around Unalaska Island.

Current herring fisheries occur within the State waters of Alaska and are managed by the ADF&G. Herring were harvested in the eastern Bering Sea EEZ by foreign fisheries from 1959 to 1980. In 1980,

PACIFIC HERRING
Alaska
COMMERCIAL CATCH (t)

YEAR	Gulf of Alaska	Bering Sea
1983	13,610	34,662
1984	18,431	28,103
1985	18,085	36,625
1986	20,725	29,324
1987	27,223	22,718
1988	29,869	22,016
1989	9,557	25,778
1990	21,389	19,140
1991	24,443	16,200
1992	34,348	31,739

PACIFIC HERRING
Gulf of Alaska and Eastern Bering Sea

	Gulf of Alaska	Bering Sea
Average catch (1977-92)	17,848 t	23,863 t
Long-term potential yield	Unknown	Unknown
Acceptable biological catch (1992)	34,348 t	31,739 t
Fishing strategy	0.1 to 0.2 of exploitable biomass	0.1 to 0.2 of exploitable biomass
Age of recruitment	3 years	4 years
Length/weight at recruitment	170 mm/85 g	220 mm/143 g
Maximum age	12 years	18 years
Abundance and trend	Moderately-high and increasing	Low and declining
Recreational importance	None	None
Subsistence use	Minor	Major
Management	Alaska Department of Fish and Game	
Assessment method	Survey, age-structured	Aerial survey, age structured
Status of exploitation	Fully utilized	Fully utilized
Natural Mortality (M)	0.45	0.27

allocations ended and herring became a prohibited species in U.S. waters.

Pacific herring exhibit a south-to-north cline in life history features. Near the southern end of their range, herring have a shorter age span, an earlier age of maturity, a higher rate of natural mortality, and a smaller size at age. In Southeast Alaska, herring mature at age 3 and have a maximum life span of about 10 years. Herring in the Togiak region, however, mature at age 4 and a maximum age of 18 years has been observed. Natural mortality also appears to increase with age in Pacific herring.

Mean length at age is greatest in herring spawning in the southeastern Bering Sea (Togiak) and decreases in herring found to the north (Norton Sound, Kotzebue). Off Southeast Alaska, the maximum size of herring is 248 mm and 210 g. In Prince William Sound (in the central Gulf of Alaska), herring grow to a maximum of 252 mm and 220 g. In the Bering Sea, maximum length and weight vary from 323 mm and 466 g in Togiak to 308 mm and 359 g in Norton Sound.

The ADF&G regulates and monitors 20 separate herring fisheries. The information from these fisheries is divided into Gulf of Alaska and Bering Sea components to provide a general overview of the catch and status of Pacific herring in Alaska by area.

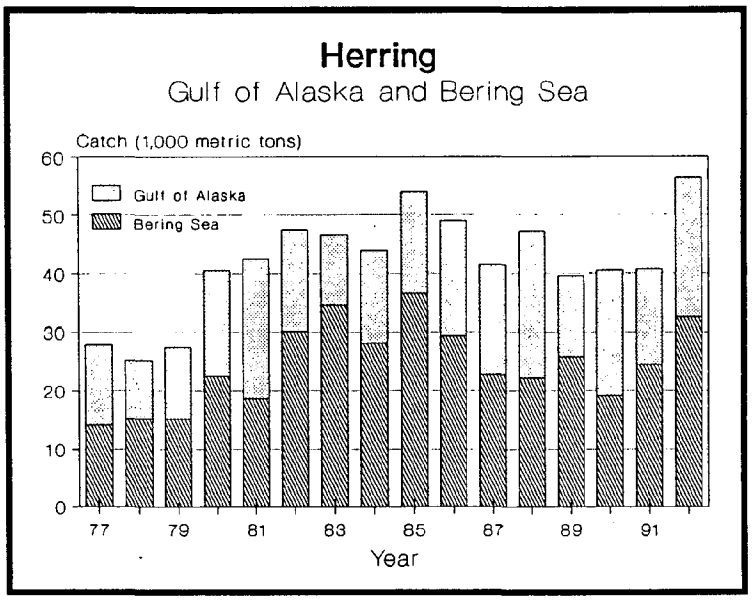
In 1992, 56,426 t of herring were harvested in Alaska with a total ex-vessel value of $30 million. The majority of the harvest was roe herring, and the remainder was food and bait herring and roe on kelp.

Gulf of Alaska -- Herring harvests in the Gulf of Alaska have averaged 19,800 t since 1977. Southeast Alaska and Prince William Sound roe-herring fisheries have accounted for the bulk of the Gulf of Alaska catch. Catches in all Gulf of Alaska herring stocks rose in 1992 due to the recruitment of a Gulf-wide strong 1988 year class.

Bering Sea -- Herring fisheries in the Bering Sea occur in spawning areas along the western Alaska coast. Major harvests occur in the Togiak area of Bristol Bay and in Norton Sound, and smaller amounts are harvested in other areas. Inshore herring fisheries developed in the late 1970s as the foreign trawl and gill-net fisheries were phased out. Catches rose from 14,000 t in 1977 to a peak catch of nearly 37,000 t in 1985. Since 1985, the catch has been declining in the southeastern Bering Sea but has been increasing in the northeastern Bering Sea. As in the Gulf of Alaska, the Bering Sea catch improved in 1992 with the recruitment of a strong

1988 year class. Norton Sound did not have a fishery in 1992 due to ice coverage of the spawning grounds.

A portion of the Bering Sea harvest is taken as bycatch in the groundfish fishery. Bycatch cannot be retained but is counted in the catch. Bycatch has averaged 2,000-4,000 t.



Stock Trends --Herring harvest levels are based on aerial surveys, spawn deposition surveys, hydroacoustic surveys, and age composition of commercial and test-fishing catches. Harvest levels are generally set at 20% of the estimated biomass, but can range down to 10%. Exploitation thresholds have been established for most stocks below which fishing is not permitted.

In the Gulf of Alaska, the overall abundance of herring is at moderate to high levels, although some stocks are depressed or declining. A strong 1984 year class is reported to be present in most fisheries. A very strong 1988 year class is reported in Southeast Alaska, Prince William Sound, and other areas are expected to further increase the abundance of herring in the Gulf of Alaska in 1993.

In the Bering Sea, the abundance of herring declined through the 1980s as the very strong 1977-78 year classes which sustained the fisheries aged and declined in abundance. In 1992, a strong 1988 year class also became evident in eastern Bering Sea stocks. This year class is expected to increase stock biomass in the near future.

For further information

Funk, F. 1993. Preliminary forecasts of catch and stock abundance for 1993 Alaska herring fisheries. Regional Information Rep. No. 5J93-06, 109 p. Alaska Dep. Fish and Game, 333 Raspberry Road, Anchorage, AK 99518.

SHELLFISH RESOURCES

By Jerry E. Reeves

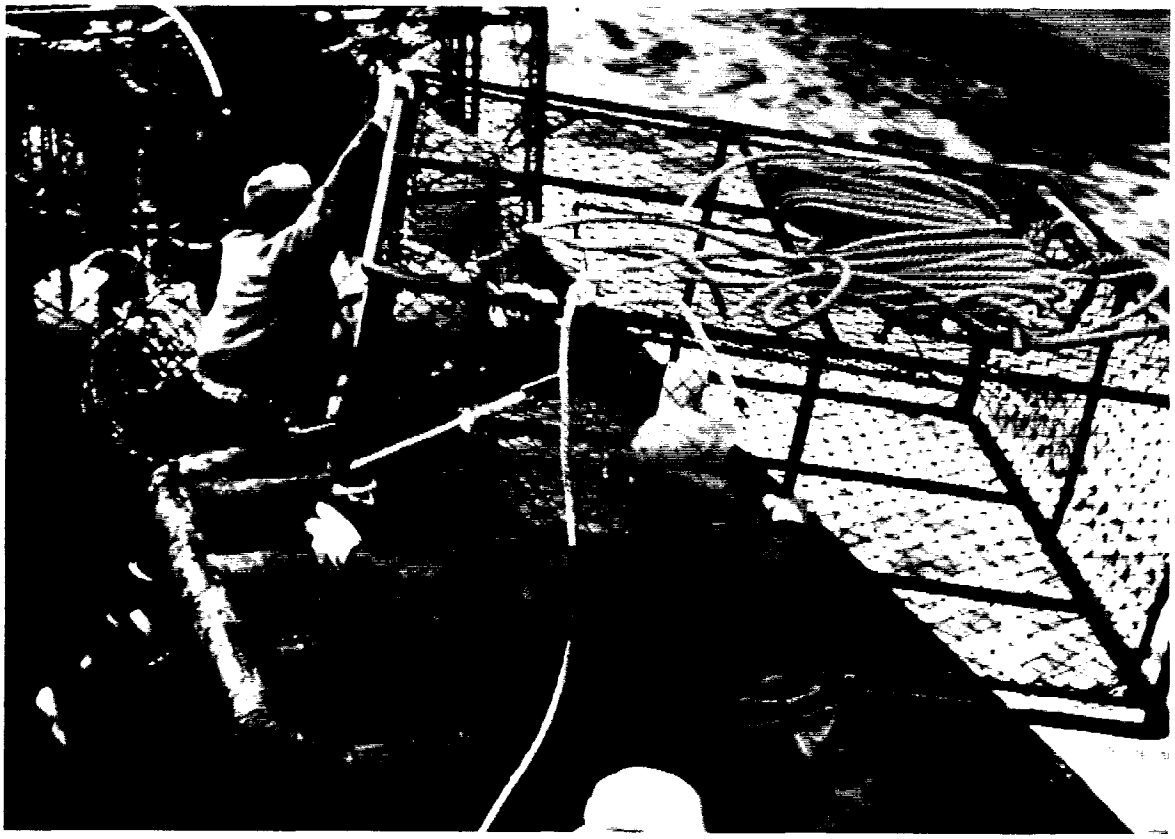


Photo: AFSC

The major shellfish resources off Alaska are king crab, Tanner crab, shrimp, and sea snails.

The king and Tanner crab fisheries of the Bering Sea and Aleutian Islands region are managed cooperatively by the State of Alaska and the Federal government. A FMP developed by the NPFMC provides for delegation of management authority to the Alaska Board of Fisheries, with the NPFMC having oversight authority. Thus the ADF&G and NMFS cooperate in assessment and management of the fisheries. Alaska shrimp and crabs in the Gulf of Alaska are managed by the Alaska Board of Fisheries. Management of Bering Sea snails is provided for by a Federal Preliminary FMP.

For crab resources, minimum size limit is the primary management measure, as is the prohibition against the landing of females. In addition, quotas, time-area closures, fishing seasons, gear restrictions and at-sea observers are used routinely for management of the stocks. Commercial crab fishing gear is restricted to pots (traps), and recreational and subsistence fisheries are insignificant compared to commercial landings except in areas which no longer have commercial harvests of former commercial species. Snail fisheries are basically undeveloped, although some limited exploratory operations have occurred in recent years.

This section focuses primarily on the crab resources of the Bering Sea and Aleutian Islands region. The ex-vessel value of this resource was $326 million in 1990 and $294 million in 1991.

22. KING CRABS

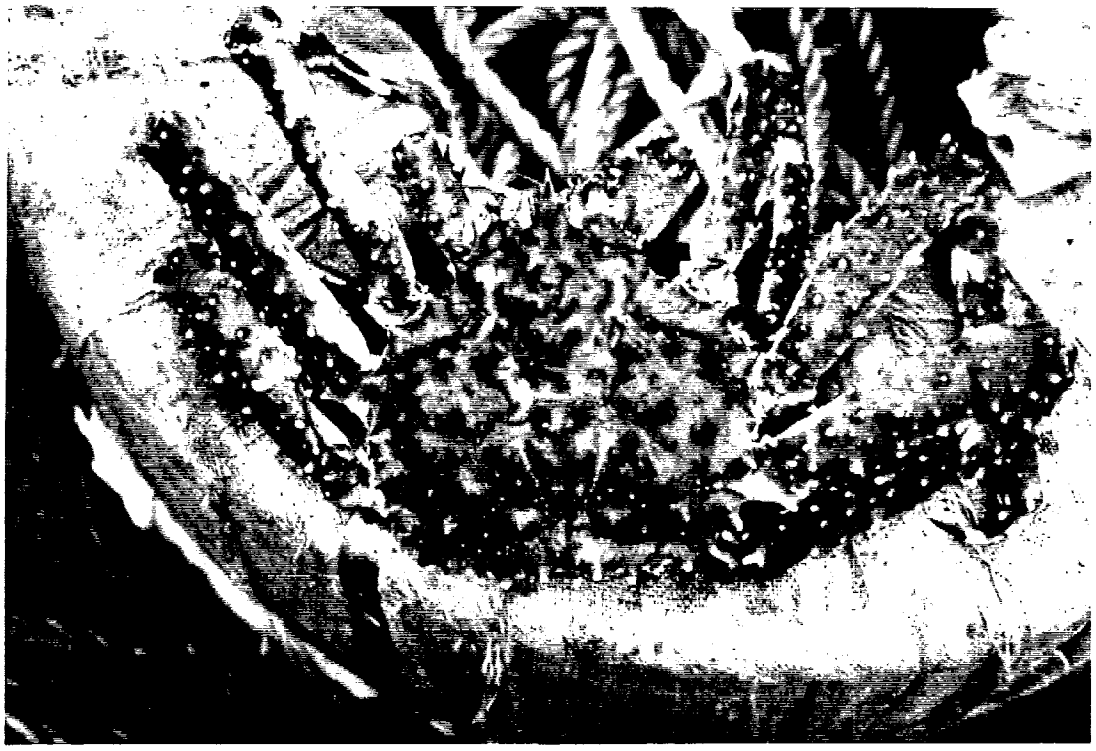
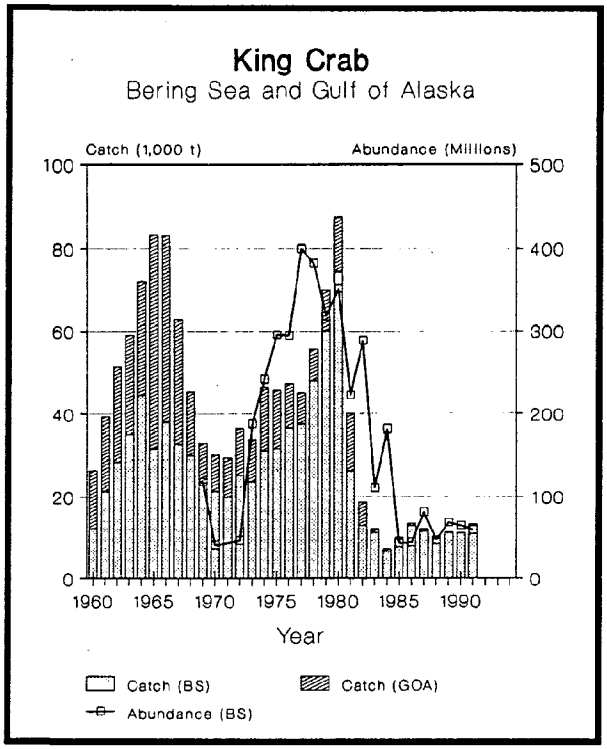


Photo: AFSC

Three species of king crab are harvested in the Bering Sea/Aleutian Islands region. These are the red king crab (*Paralithodes camtschaticus*), the blue king crab (*P. platypus*), and the brown or golden king crab (*Lithodes aequispina*). The red king crab fishery has the longest commercial history and highest yield and value when compared to the other two king crab species. Ex-vessel value of king crab landings declined 38%, from $132 million in 1990 to $82 million in 1991.



Red King Crab

Red king crabs are distributed in the shelf waters of the North Pacific and Bering Sea from the Japan Sea to northern British Columbia, and may attain carapace lengths in excess of 200 mm (8 in). The minimum size limit is usually 165 mm (6.5 in) carapace width, and individuals in the catch commonly average 2.5-3.0 kg (6-7 lb). For most stocks, male and female size at 50% maturity is considered to be 120 mm and

90 mm carapace lengths, respectively (4.7, 3.5 in). Corresponding approximate ages of maturity are 6 and 5 years.

Four stocks of red king crabs are identified for management in the Bering Sea/Aleutian Islands region: the Bristol Bay, Norton Sound, Dutch Harbor, and Adak stocks. Fisheries are conducted primarily in the fall and winter. Red king crab landings decreased 16% from 9,721 t in 1990 to 8,178 t in 1991, and value decreased 49% from $105.1 in 1990 to $54.0 million in 1991. All stocks are at low levels of abundance compared to historic levels.

Bristol Bay stock -- The 1991 catch of red king crab in Bristol Bay decreased 16% from 1990 (9,236 t to 7,792 t), and remained below average for this stock, and substantially below the record high production of 59,000 t in 1980. Effort by 302 vessels making 324 landings during the 1- 8 November season decreased 13% from 1990 (262,131 to 227,555 pot lifts). The CPUE (number of legal crabs per pot lift) remained unchanged at 12.

The 1991 NMFS summer survey indicated that abundance declined from the 1990 level. The abundance of males greater than 109 mm and females greater than 89 mm carapace length, corresponding approximately to the mature stock, was 31 million male crabs in 1991 compared to 37 million in 1990. The stock of legal males increased from 9 million in 1990 to 12 million in 1991. Prerecruit male abundance in 1991 declined from 10 to 6 million crabs. The abundance of mature females declined from 18 to 13 million crabs, and the spawning stock remains below average. Fishing mortality on the mature stock in 1990 was below F_{MSY}.

Dutch Harbor stock -- The Dutch Harbor red king crab fishery has been closed since 1982 when 196 t were landed. The 1991 trawl survey conducted by ADF&G indicated a low level of abundance for this stock. Based on the continuing low stock condition observed in 1987, 1990, and 1991 ADF&G surveys, the fishery remained closed in 1991.

RED KING CRAB
Bering Sea/Aleutians Region
Commercial Landings (t)

YEAR	Bristol Bay	Dutch Harbor	Adak	Norton Sound	TOTAL
1983	0	0	899	183	1,082
1984	1,897	0	620	193	2,710
1985	1,894	0	411	208	2,513
1986	5,168	0	323	235	5,726
1987	5,574	0	551	159	6,284
1988	3,351	0	711	113	4,175
1989	4,656	0	507	120	5,283
1990	9,236	0	376	109	9,721
1991	7,792	0	431	15	8,178
1992	3,629	0	n.a.	58	

RED KING CRAB
Bering Sea/Aleutians Region

		Bristol Bay	Dutch Harbor	Adak	Norton Sound
Long-term potential catch (t)		15,948	2,653	1,395	344
Importance of non-commercial fishery		minor	minor	minor	minor
Management		By State of Alaska and Federal FMP			
Status of exploitation		All stock are fully exploited			
Age at 50% maturity	males	6	unknown	unknown	unknown
	females	5	unknown	unknown	unknown
Size at 50% maturity	males	120	120	120	90
Carapace length(mm)	females	90	90	90	70
Assessment method		Spawning stock	Index	Index	Index
Parameters (mature males)					
M		0.3	0.3	0.3	0.3
F(0.1)		0.35	0.35	unknown	0.35
F(MSY)		=F(0.1)	=F(0.1)	=M	=F(0.1)
F(91)		0.18	unknown	unknown	0.02

Adak stock -- The 1991 red king crab catch of 371 t at Adak remained similar to the 1990 catch and remained below high production levels of the 1960s and 1970s. Effort by seven vessels making 24 landings during the 1 November-15 February season increased 7% over 1990 (10,674 to 11,407 pot lifts). Catch per unit effort decreased from 14 to 12.

The Adak stock has not been surveyed since 1977, but the ADF&G Mandatory Observer Program instituted in 1988 provides data on stock condition. This information indicates the stock is stable but depressed in comparison to historic catch levels. Fishing mortality in 1991 was unknown.

Norton Sound stock -- The 1991 catch of red king crab in Norton Sound decreased 86% from 1990 (109 to 15 t), and was below the recent-year average. This amount was caught during the winter commercial fishery and by subsistence permit holders. There was no summer commercial fishery in 1991.

The stock was surveyed in 1991 by NMFS. Results indicate a population of mature crabs of 2.1 million, down somewhat from the 2.5 million estimated in 1988. Fishing mortality in 1990 was below F_{MSY}.

BLUE KING CRAB
Bering Sea/Aleutians Region
COMMERCIAL LANDINGS (t)

Year	Pribilofs	St.Matthew	Total
1983	995	4,288	5,283
1984	139	1,708	1,847
1985	242	1,101	1,343
1986	117	455	572
1987	318	488	806
1988	0	601	601
1989	0	529	529
1990	0	783	783
1991	0	1,530	1,530
1992	0	1,134	1,134

BLUE KING CRAB
Bering Sea/Aleutians Region

	Pribilofs	St. Matthew
Long-term potential catch (t)	1,545	1,276
Importance of non-commercial fishery	Minor	Minor
Management	State/ Fed.FMP	State/ Fed.FMP
Status of exploitation	Fully-Exploited	Fully-Exploited
Age at 50% maturity	Unknown	Unknown
Size at 50% maturity males	120	105
Carapace length(mm) females	90	80
Assessment method	Index	Index
Parameters (mature males)		
M	0.3	0.3
F(0.1)	0.35	0.35
F(MSY)	=F(0.1)	=F(0.1)
F(91)	0.00	0.22

Blue King Crab

Blue king crabs are distributed in the continental shelf waters of the North Pacific Ocean and Bering Sea from the Japan Sea to the waters off Southeast Alaska, although they do not occur in the Aleutian Islands region. Two stocks of blue king crabs are identified for management in the Bering Sea region: the Pribilof Islands stock and the St. Matthew Island stock. These two stocks have noticeably different characteristics. Blue king crabs in the Pribilof Islands may attain a carapace length in excess of 200 mm (8 in). The minimum size limit is 165 mm (6.5 in) carapace width, and individuals in the catch commonly average 3.0-3.5 kg (7-8 lb). Male and female size at 50% maturity is considered to be 120 mm and 90 mm carapace length, respectively. Blue king crabs of the St. Matthew stock are smaller. The fishery is managed with a minimum size limit of 140 mm carapace width, and individuals in the catch average 2.0-2.5 kg (4-5 lb). Size at 50% maturity for males and females is 105 mm and 80 mm carapace length, respectively. Fisheries are conducted in the fall. Blue king crab landings increased 95% in 1991 (783 t to 1,530 t), with commercial value increasing 63% ($5.8 to $9.4 million). Both stocks are at low levels.

Pribilof Islands stock -- The blue king crab fishery around the Pribilof Islands has been closed since 1987 when 318 t were landed. The 1991 NMFS summer survey indicated that abundance of the mature stock increased over 1990 but still remains at a relatively low level. Males greater than 109 mm and females greater than 89 mm carapace length,

corresponding approximately to the mature stock, increased to 4.8 million crabs in 1991 compared to 4.3 million in 1990. The stock of legal males increased from 0.4 to 1.0 million crabs in 1991. Prerecruit male abundance decreased somewhat in 1991. The abundance of mature males, considered an index of spawners, was unchanged in 1991. The stock has been at a depressed level since 1984 but, as indicated by prerecruit abundance, is now showing some signs of recovery.

St. Matthew Island stock -- The 1991 blue king crab catch around St. Matthew Island increased 95% over 1990 (783 t to 1,530 t) but remained below average and substantially below the high production years 1982 and 1983. Effort by 68 vessels making 69 landings during the 16-20 September season increased 41% from 1990 (26,264 to 37,104 pot lifts). Catch per unit effort increased 33% (15 to 20). The 1991 NMFS summer survey indicated that abundance increased over the 1990 level. The abundance of males greater than 104 mm and females greater than 79 mm carapace length, corresponding approximately to the mature stock, was 4.4 million crabs in 1991 compared to 2.6 million in 1990. The stock of legal males, 1.7 million crabs in 1990, was 2.2 million in 1991. Prerecruit male abundance was 1.5 million in 1991, compared to 0.8 million in 1990. The abundance of mature males, used as an index of the spawning stock, was 3.7 million in 1991 compared to 2.4 million in 1990. Fishing mortality on the mature male stock in 1991 was below F_{MSY}.

Brown King Crab

Brown (golden) king crabs are distributed in the continental slope waters of the North Pacific Ocean and Bering Sea from Japan to British Columbia. In

BROWN KING CRAB
Bering Sea/Aleutians Region
Commercial Landings (t)

YEAR	Adak	Dutch Harbor	Pribilof	Northern	TOTAL
1983	3,687	821	388	0	4,335
1984	1,442	690	0	0	2,132
1985	5,046	893	c	0	5,939
1986	5,805	848	c	0	6,653
1987	3,629	627	c	193	4,449
1988	4,119	701	c	73	4,893
1989	4,610	840	c	c	5,450
1990	2,382	780	0	0	3,162
1991	2,837	657	0	0	3,494

c = confidential

BROWN KING CRAB
Bering Sea/Aleutians Region

		Adak	Dutch Harbor	Pribilof	Northern
Long-term potential catch (t)		3,146	681	0	37
Importance of non-commercial fishery		Minor	Minor	Minor	Minor
Management		-- By State of Alaska and Federal FMP --			
Status of exploitation		Unknown	Unknown	Under-Exploited	Under-Exploited
Age at 50% maturity	males	Unknown	Unknown	Unknown	Unknown
	females	Unknown	Unknown	Unknown	Unknown
Size at 50% maturity	males	109-130	130	107	92
Carapace length(mm)	females	106-113	111	100	98
Assessment level		Index	Index	Index	Index
Parameters (mature males)					
M		0.3	0.3	0.3	0.3
F(0.1)		Unknown	Unknown	Unknown	Unknown
F(MSY)		= M	= M	= M	= M
F(91)		Unknown	Unknown	0	0

most management areas the minimum size limit is 152 mm (6.0 in) carapace width, and individuals in the catch commonly average 1.4-2.3 kg (3-5 lb). Male and female size at 50% maturity is in the range of 92-130 mm and 98-111 mm carapace length, respectively.

Four stocks of brown king crabs are identified for management in the Bering Sea/Aleutian Islands region: Adak, Dutch Harbor, Pribilof Islands, and Northern Bering Sea stocks. Fisheries are conducted in the fall through the spring. Brown king crab landings increased 10% from 1990 to 1991 (3,162 t to 3,494 t), but value decreased 11% from $20.92 to $18.5 million.

Adak stock -- The 1991 brown king crab catch from Adak increased 19% over 1990 (2,382 t to 2,837 t). Effort by 16 vessels making 206 landings during the 1 November-15 August season increased 20% over 1990 (160,960 to 192,949 pot lifts). Catch per unit effort remained the same at 8 legals per pot.

This stock has not been surveyed. Fishing mortality on the stock in 1991 was unknown.

Dutch Harbor stock -- The 1991 catch from the Dutch Harbor brown king crab stock decreased 16% from 1990 (780 t to 657 t). Effort by 11 vessels making 50 landings during the 1 September-15 November season decreased 26% over 1990 (54,618 to 40,604 pot lifts). Catch per unit effort of legal males was 8.

This stock has not been surveyed, and fishing mortality on the mature stock in 1991 was unknown.

Pribilof Islands and Northern Bering Sea stocks -- Fisheries in these districts have been sporadic during the last 10 years. No effort was expended in the Northern Bering Sea in 1991. No population estimates are available for these stocks, and while no estimates of F are available due to limited fishery data, F is probably below F_{MSY}.

For further information

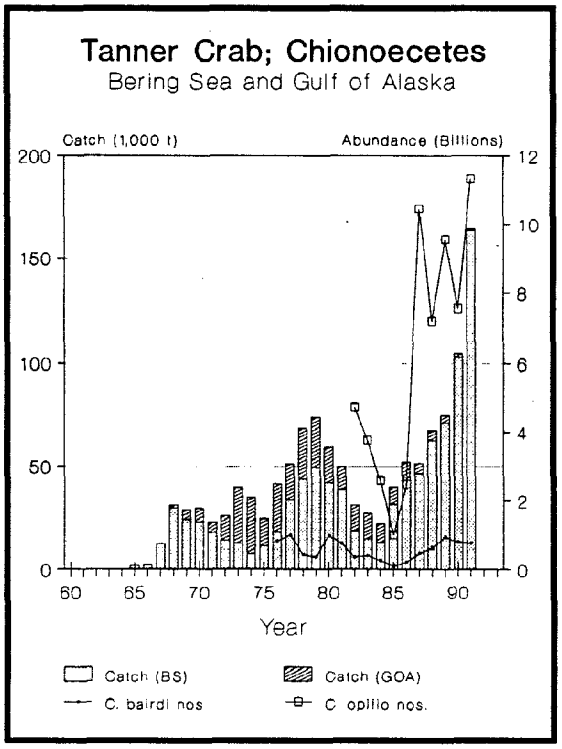
Alaska Department of Fish and Game. 1992. Annual management report for the shellfish fisheries of the Westward region, 1991, Regional Information Report 4K92-9, 216 p. Div. Comm. Fish., 211 Mission Rd., Kodiak, AK, 99615.

Stevens, B.G., R.A. MacIntosh, J.A. Haaga, and J.H. Bowerman. 1993. Report to industry on the 1993 eastern Bering Sea crab survey. AFSC Processed Rep. 93-14, 53 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, P.O.Box 1638, Kodiak, AK 99615.

23. TANNER AND SNOW CRABS

Photo: AFSC

Two species of *Chionoecetes* crabs are harvested in the Bering Sea/Aleutian Islands region: *C. bairdi*, commonly known as the Tanner crab, and *C. opilio*, commonly known as the snow crab. During the 1960s and 1970s *C. bairdi* stocks provided the major production of *Chionoecetes* crab. Since the early 1980s, *C. opilio* has been the major Tanner crab species harvested in Alaska. Landed value of these fisheries increased from $194 million to $212 million from 1990 to 1991.



Tanner crab

Tanner crabs are distributed on the continental shelf of the North Pacific Ocean and Bering Sea from Kamchatka to Oregon. The males of this species may attain a carapace width in excess of 180 mm (7 in). The minimum size limit is 140 mm (5.5 in) carapace width, and individuals in the catch commonly average 0.9-1.1 kg (2-2.5 lb). Male and female size at 50% maturity is considered to be 110 mm and 90 mm carapace width, respectively. The corresponding approximate age of maturity is 6 years.

Three stocks of Tanner crabs are identified for management in the Bering Sea/Aleutian Islands region: Bering Sea, Eastern Aleutians, and Western Aleutians stocks. Fisheries are conducted primarily in the winter and spring. Tanner crab landings decreased 51% in 1991 (29,416 t to 14,453 t). Ex-vessel value of the fisheries was $47.8 million in 1991.

Bering Sea stock -- The 1991 catch of Bering Sea Tanner crabs decreased 51% from 1990 levels (29,316 t to 14,423 t). This drop is an artifact of season changes occuring in 1990. The catch has actually been on an increasing trend which began in 1988. Effort by 258 vessels making 761 landings during the 15 November-31 March season decreased 44% from 1990 levels (883,391 to 499,277 pot lifts). Catch per unit effort increased from 19 to 21.

The 1991 NMFS summer survey indicated the stock continued to increase as it has in the last few years. The abundance of males greater than 109 mm and females greater than 84 mm carapace width, corresponding approximately to the mature stock, was 268 million crabs in 1991, compared to 230 million in 1990. The mature stock has been increasing since 1985. The stock of legal males decreased from 54 million in 1990 to 46 million in 1991. Prerecruit male abundance in 1991 was up from 1990 levels (79 million to 105 million). The abundance of mature males has likewise increased (133 million in 1990 to 151 million in 1991). Fishing mortality on the mature stock in 1991 was below F_{MSY}.

Eastern Aleutians stock -- The catch of Tanner crab from the Eastern Aleutians stock in 1991 decreased 71% below 1990 levels (78 t to 23 t). Effort by five vessels making 27 landings during the 15 January-31 March season decreased 73% from 1990 (6,858 to 1,849 pot lifts). Catch per unit effort increased from 11 to 12. A survey of this stock by the ADF&G during summer 1991 indicated a very small *C. bairdi* population. Fishing mortality in 1991 was unknown.

Western Aleutians stock -- Tanner crab landings from the Western Aleutians stock in 1991 decreased 68% below 1990 levels (22 to 7 t). Effort by five vessels making 21 landings during the 1 November-25 March season decreased 79% from 1990 (6,204 to 1,309 pot lifts). Catch per unit effort increased from 4 to 5. With the exception of a few of the smaller vessels in this district, the catch of Tanner crabs is considered incidental to the red and brown king crab fisheries in the same area. The current level of fishing mortality on this stock is unknown.

TANNER CRAB (Chionoecetes bairdi)
Bering Sea/Aleutians Region
Commercial Landings (t)

YEAR	Bering Sea	Eastern Aleutian	Western Aleutian	TOTAL
1983	2,392	248	222	2,862
1984	548	109	174	831
1985	1,430	75	74	1,579
1986	0	76	94	170
1987	0	73	19	92
1988	1,003	141	64	1,208
1989	3,181	148	68	3,397
1990	29,316	78	22	29,416
1991	14,423	23	7	14,453

TANNER CRAB (Chionoecetes bairdi)
Bering Sea/Aleutians Region

	Bering Sea	Eastern Aleutian	Western Aleutian
Long-term potential catch (t)	11,574	266	89
Importance of non-commercial fishery	----------	Minor	----------
Management	-----	State/Federal FMP	------
Status of exploitation	Fully-exploited	Unknown	Unknown
Age at 50% maturity (both sexes)	6	Unknown	Unknown
Size at 50% maturity (males)	110	Unknown	Unknown
Carapace width(mm) (females)	90	Unknown	Unknown
Assessment method	Yield	Index	Index
Assessment parameters (mature males)			
M	0.3	0.3	0.3
F(0.1)	0.34	Unknown	Unknown
F(MSY)	= F(0.1)	= M	= M
F(91)	0.09	Unknown	Unknown

Snow crab

SNOW CRAB (Chionoecetes opilio) Bering Sea	
Stock	= Bering Sea
Long-term potential catch	= 28,951 t
Importance of non-commercial fishery	= Minor
Management	= State/Fed.FMP
Status of exploitation	= Fully-exploited
Age at 50% maturity (males & females)	= 4
Size at 50% maturity males	= 65
Carapace width(mm) females	= 50
Assessment level	= Yield
Assessment parameters (mature males)	
M	= 0.3
F(0.1)	= 0.25
F(MSY)	= F(0.1)
F(91)	= 0.16

Snow crabs (*C. opilio*) are distributed on the continental shelf of the Bering Sea, Chukchi Sea, and in the western Atlantic Ocean as far south as Maine. A subspecies, *C.o. elongatus*, occurs from the Japan Sea to the Okhotsk Sea. The males of this species may attain a carapace width in excess of 152 mm (6 in). In U.S. waters a market minimum size of about 102 mm carapace width is in effect, and individuals in the catch commonly average 0.5-0.7 kg (1-1.5 lb). Male and female size at 50% maturity is considered to be 65 mm (2.6 in) and 50 mm (2.0 in) carapace width, respectively. The corresponding approximate age of maturity is 4 years.

Snow crabs of the eastern Bering Sea are considered to be one stock. Fisheries are conducted primarily in the winter and spring. Snow crab landings jumped 103% in 1991 (73,402 to 149,073 t), and value increased 59% ($103.6 to $164.3 million). Effort by 228 vessels making 2,788 landings during the 15 January -23 June season increased 53% over 1990 (911,613 to 1,391,583 pot lifts). Catch per unit effort increased 35% (139 to 188 legal crabs per pot lift). The 1991 NMFS summer survey indicated that the mature stock remains high. Abundance of males greater than 64 mm and females greater than 49 mm carapace width, corresponding approximately to the mature stock, was 5,215 million crabs in 1991, compared to 4,748 million in 1990. Abundance of large males increased from 420 million in 1990 to 484 million in 1991. Prerecruit male (80-104 mm) abundance in 1991 decreased from 1990 (1,077 million to 708 million). The abundance of mature males decreased from 1,949 to 1,640 million. Fishing mortality on the mature stock in 1991 was below F_{MSY}.

SNOW CRAB (Chionoecetes opilio) Bering Sea Commercial Landings (t)	
1983	11,852
1984	12,162
1985	29,937
1986	44,445
1987	46,223
1988	60,809
1989	67,793
1990	73,402
1991	149,073
1992	143,020

For further information

Alaska Department of Fish and Game. 1992. Annual management report for the shellfish fisheries of the Westward region, 1991, Regional Information Report 4K92-9, 216 p. Div. Comm. Fish., 211 Mission Rd., Kodiak, AK, 99615.

Stevens, B.G., R.A. MacIntosh, J.A. Haaga, and J.H. Bowerman. 1993. Report to industry on the 1993 eastern Bering Sea crab survey. AFSC Processed Rep. 93-14, 53 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, P.O.Box 1638, Kodiak, AK 99615.

24. SHRIMP AND SEA SNAILS

Photo: AFSC

The U.S. fishery for shrimp in Alaskan waters is currently at a low level. The western Gulf of Alaska has been the main area of operation. During the 1970s, when the fishery was at a higher level of productivity, from 50 to 100 vessels trawled for shrimp (primarily Northern pink shrimp, *Pandalus borealis*) off Kodiak and along the Alaska Peninsula. Stocks are managed by regulating the level of exploitation rates according to the level of the stocks. In addition, spring "egg hatch" closures are utilized to protect breeding stocks.

From the 1960s, catches rose steadily to about 58,000 t in 1976, and declined precipitously after that time. Since 1988, no shrimp has been landed from western Alaska. During the 1960-90 period, the ex-vessel value of western Alaska shrimp fisheries averaged $4 million annually, with a peak value of $14 million in 1977.

Shrimp catches by the U.S.S.R. and Japan in the Bering Sea rose to a peak of 32,000 t in 1963, and gradually declined thereafter, until the fishery ceased operation in 1973. The potential yield for shrimp stocks is not well understood. The LTPY has been estimated using the 20-year average catch.

The snail resource of the eastern Bering Sea is composed of about 15 species which are patchily distributed over the continental shelf. *Neptunea pribiloffensis* is probably the most abundant species, with other members of the genus, *N. lyrata*, *N. ventricosa*, and *N. heros* also very common. Mean shell lengths for these species range from 100 to 120 mm. *Fusitriton oregonensis* is another abundant species and reaches a length of 130 mm (5.1 in). Several species of the genus *Buccinum* are also common to the area, but they are smaller with average shell lengths ranging 58 to 75 mm. Most species are restricted to specific depth and temperature regimes. *Neptunea pribiloffensis* and *N. lyrata* are typically found in deeper, warmer waters at the shelf edge, while *N. heros* and *N. ventricosa* inhabit shallower coastal waters. *Neptunea pribiloffensis*, *N. lyrata*, and *F. oregonensis* make up the bulk of the snail

SEA SNAILS
Bering Sea/Aleutians
Commercial Catch (t)

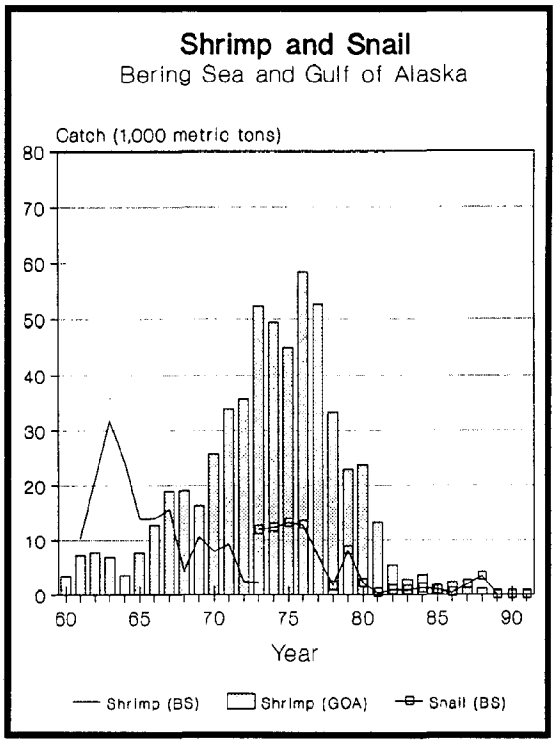
YEAR	CATCH
1982	841
1983	1,207
1984	852
1985	389
1986	1,826
1987	3,267
1988	0
1989	0
1990	0
1991	0

biomass in the eastern Bering Sea.

Life histories are similar among species. Sexes are separate and fertilization is internal. Among larger species, maturity occurs at 90-110 mm lengths, which probably correspond to an age of about 10 years. Young are hatched from egg capsules, and almost all species have no larval stages. Egg cases are usually laid on both live and dead shells of large snails, and vary in the number of individual capsules they contain. Little is known regarding feeding habits of snails, but they are probably predators and scavengers.

Japan has harvested snails from the eastern Bering Sea since at least 1971, the last year of operation being 1987. The average annual catch of whole animals during that period was approximately 4,800 t. Only fragmentary information is available regarding other aspects of this fishery. *Neptunea pribiloffensis* accounted for 70% of the catch and meat yields were about 30%. Probably less than 20 vessels participated in the fishery annually, ranging in size from 96 to 490 gross t, and similar to vessels used in Japanese longline and crab fisheries off Alaska. Fishing gear consisted of baited pots (traps) attached at intervals along groundlines. Ex-vessel value in the late 1970s ranged between $600 and $1,657 per t, with the value of the 1978 catch estimated at $1.3 million.

There is currently no U.S. fishery for snails in the Bering Sea, although one vessel was permitted to fish in 1990. There are no estimates of biomass available, and fishing mortality and other population parameters are unknown.



SEA SNAILS
Bering Sea/Aleutians Region

Long-term potential catch	= 4,800 t
Importance of recreational fishery	= None
Management	= PFMP
Status of exploitation	= Underexploited
Spawning stock abundance	= Unknown
Age at 50% maturity (male and female)	= 10
Size at 50% maturity (male and female) Shell length (mm)	= 90-110
Assessment method	= History
Assessment parameters	= Unknown

For further information

MacIntosh, R.A. 1980. The snail resource of the eastern Bering Sea and its fishery. Mar. Fish. Rev. 42(5):15-20.

ALASKA SALMON RESOURCES

By James C. Olsen

Photo: AFSC

The Pacific salmon fisheries in Alaska contribute to the food supply and economy of the Nation and rank as the largest non-governmental employer in Alaska with recent sales exceeding those of tourism, mining, or forest products. The fisheries provide recreational opportunities and are an integral part of Alaska native culture and heritage. Recent catches exceed 155 million salmon and include about 20 million salmon from the Alaska enhancement projects. Ex-vessel value of the 1992 catch was about $575 million.

Pacific salmon are anadromous. Their life cycle begins with the deposition of eggs by spawning adults in redds (nests) dug in streambeds or lake bottoms. Some pink and chum populations spawn in or just above intertidal areas. Eggs incubate several months in the gravel before the young salmon (alevins) are ready to hatch. After hatching the alevins remain in the gravel nourished by the egg yolk before emerging from the gravel as ready-to-feed salmon fry. There are three basic patterns of freshwater rearing for Pacific salmon: (1) migration to saltwater upon emergence from the gravel, typical of pink and chum salmon; (2) short-term rearing in fresh water with migration to sea in the first year of life, typical of ocean-type (fall) chinook, some sockeye, and some chum populations; and (3) at least one winter rearing in freshwater streams or lakes after emergence with migration to sea at age I or older; typical of coho, stream type (spring) chinook, and most sockeye populations.

In the North Pacific Ocean, salmon from Alaska feed with other North American stocks and migrate thousands of miles and mix with stocks from Asia. Some stocks will migrate into international waters outside of the U.S. EEZ. Length of stay in the ocean varies with species from 1 year to 6 years. Pink and coho salmon typically spend one winter at sea; chum and sockeye salmon spend from 2 to 5 years; and chinook salmon may spend up to 6 years. Growth in ocean areas is rapid. Average

weight at maturity is 3-5 lb for pink, 5-8 lb for sockeye, 10-15 lb for chum, 7-12 lb for coho, and 17-50 lb for chinook salmon. As Alaska stocks return to natal spawning areas, they mix with stocks from British Columbia, the Yukon Territory and the Pacific Northwest along the Alaska coast.

Management of Pacific salmon in the vast Alaska region requires a complex mixture of domestic and international bodies, treaties, regulations, and agreements. Salmon management in the EEZ is under the responsibility of NMFS and the NPFMC for the coast of Alaska from 3 to 200 miles offshore. In state waters, where most fisheries occur, fisheries are managed by the ADF&G. Catches of Alaska salmon in high-seas fisheries outside the U.S. EEZ can be significant. As of 1993, the high-seas salmon fishery of Japan has been terminated under a new "Convention for the Conservation of Anadromous Stocks for the North Pacific Ocean." The other type of high-seas fishery that can catch significant numbers of salmon, the squid-driftnet fishery, has also been terminated under the United Nation's General Assembly Resolution 46/215.

The complexity of managing fisheries on mixtures of salmon stocks from several regions and from two countries is illustrated by the Pacific Salmon Treaty between the United States and Canada. Signed in 1985, the Treaty established the Pacific Salmon Commission (PSC) and provides principles for salmon stock management to reduce interceptions and to establish equity in catches off the Pacific Northwest, British Columbia, and Southeast Alaska. The U.S agencies involved include state management agencies in Oregon, Washington, Idaho, and Alaska; Pacific Northwest Indian tribal governments; and U.S. Departments of State, Commerce, and Interior. Agreements from the Treaty are assisting in rebuilding depressed chinook salmon stocks; in Southeast Alaska, chinook catch ceilings provide for hatchery "add-ons" to allow harvest of salmon from Alaska hatcheries. The Treaty sets catch allocations for British Columbia sockeye salmon stocks caught in southern Southeast Alaska traditional net fisheries. Agreements have been reached on harvest allocations and bilateral enhancement for transboundary river sockeye salmon. Pink salmon catch ceilings have been set to reduce interceptions of Alaska pink salmon by Canada in boundary fishing areas between British Columbia and Alaska.

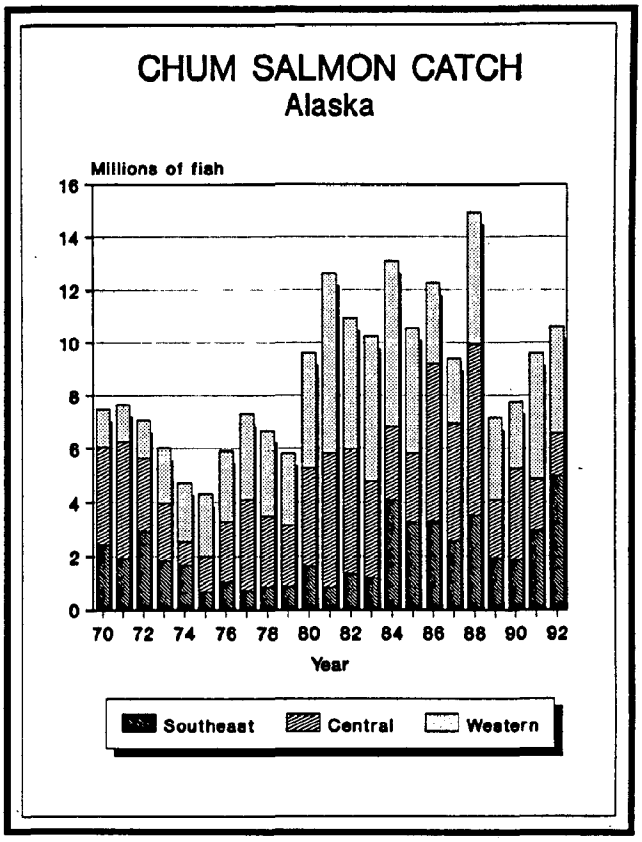
In Alaska, all five species of Pacific salmon are fully utilized. Most stocks have generally rebuilt to or beyond previous high levels. On a regional basis, some stocks are not rebuilding and may be overutilized and may be at risk. Declining escapement of some stocks in the three ADF&G management regions (southeast, central, and western) has been observed. The reasons for the declines are not fully understood but causes may include impacts on spawning and rearing habitats from industrial activities, decreasing ocean temperatures, reduced food abundance at early life stages, bycatches in other fisheries, illegal high-seas fishing, and competition in ocean feeding areas from Asian hatchery salmon.

25. CHUM SALMON

Chum salmon (*Oncorhynchus keta*) have the widest natural geographic distribution of all Pacific salmon species. They range throughout Alaskan waters from the Southeast Region into the Bering Sea and to northern Alaska in the Arctic Ocean to the Mackenzie River in Canada.

Chum salmon often spawn in large rivers and stream areas where upwelling ground water is present. In some areas, they can be found spawning in the same places as pink salmon (*O. gorbuscha*) including the intertidal reaches of rivers. Some chum salmon travel long distances in rivers before spawning. In the Yukon River, chum salmon may migrate over 2,800 km to return to natal spawning grounds.

In the fall, the female salmon lays up to 2,700 eggs in the stream gravel. After hatching the following spring, the fry usually move downstream and by fall have entered the ocean. They remain in the ocean from 2 to 4 years feeding in the same areas as salmon from Canada, Japan, and Russia. Chum salmon vary in size at maturity and average about 3-8 kg. Some may weigh as much as 20 kg.



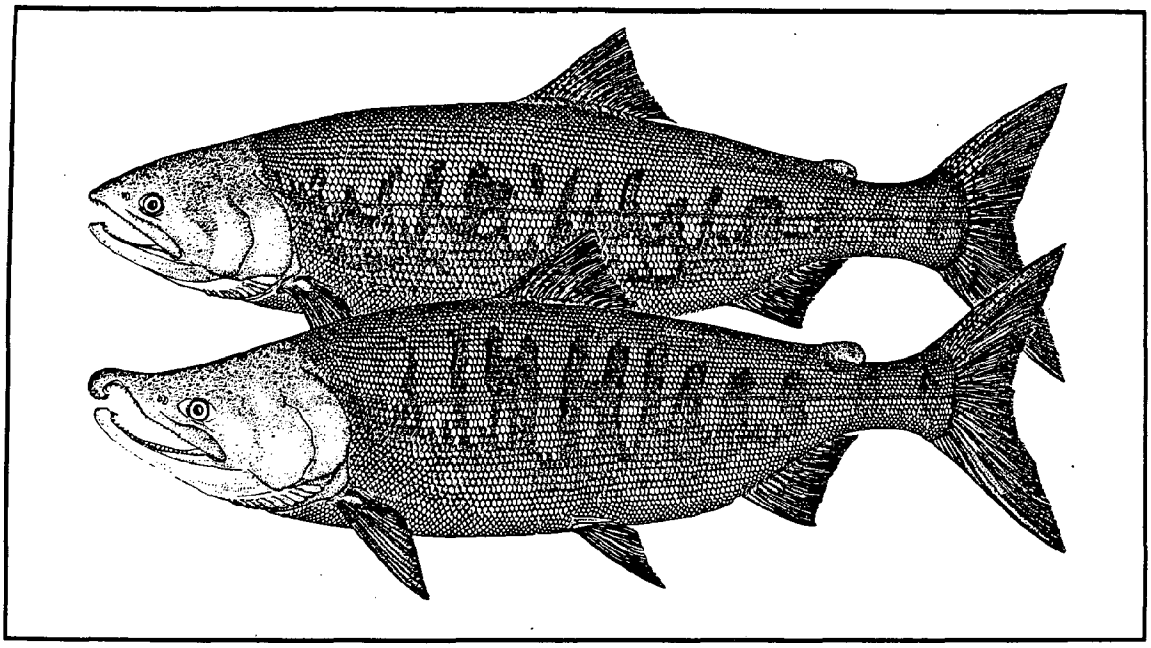
Most chum salmon are caught in near-shore gill net and purse seine fisheries. Catches averaged between 5.4 million and 7.8 million fish until the 1980s and were generally incidental to pink salmon catches. During the 1980s, market demands for chum salmon increased as the availability of other salmon decreased and fresh and frozen chum salmon from Alaska were marketed in Japan and northern Europe. The State of Alaska began hatchery production of chum salmon in the 1980s. From 1990 to 1992, about 24% of the catch in the southeast and central regions has been from hatcheries.

On a statewide basis, chum salmon populations are fully utilized but abundance, as reflected by catches, remains well below historic levels. The status of the wild stocks is difficult to determine. Catch data generally do not reflect abundance of this species because chum salmon are usually not a target species in net fisheries that are directed at sockeye and pink salmon and spawning escapement counts are generally inexact.

Stocks in the western region may have been impacted by foreign high-seas driftnet fisheries for squid and salmon. Large numbers of chum

CHUM SALMON
Alaska
COMMERCIAL CATCH
(1,000s of fish)

Ten Year period	Average catch
1890-99	10
1900-09	899
1910-19	6,656
1920-29	7,559
1930-39	7,636
1940-49	7,830
1950-59	6,244
1960-69	5,386
1970-79	6,299
1980-89	11,143
1990-92	9,214



salmon were caught, but country-of-origin data are sparse. These fisheries ended in December 1992 with the United Nations' moratorium on pelagic driftnet fishing. Illegal high-seas fishing in areas where North American salmon occur remains a concern and has an unknown impact on stocks. More research is needed to establish baseline data so that Pacific salmon of North American and Asian origin can be identified and to increase understanding of distribution and competition with other species in ocean feeding areas.

Conservation of some stocks in the southern southeast region is a concern where lower-than-average returns to spawning areas have been observed and runs have not rebuilt to historic high levels as have pink salmon in the same region. Reasons for the declines are not fully understood but may be due to changes in ocean growth and survival, overharvesting of stocks by coastal fisheries, and degradation in freshwater habitats.

CHUM SALMON
Alaska

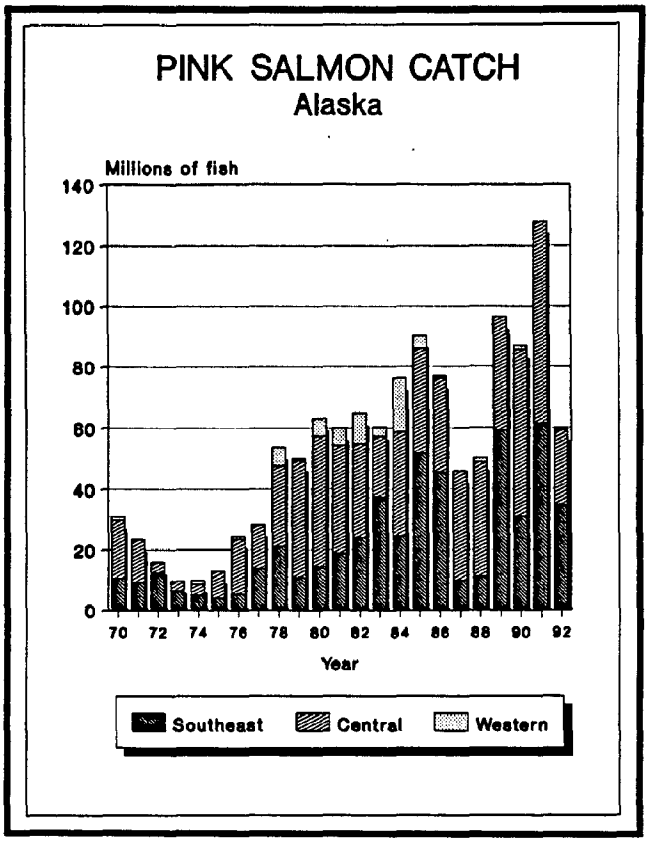
Average catch (1980-92):	Alaska	= 38,192 t
	Southeast region	= 10,771 t
	Central region	= 13,339 t
	Western region	= 14,082 t
Average catch (1990-92):	Alaska	= 31,668 t
	Southeast region	= 12,537 t
	Central region	= 7,831 t
	Western region	= 11,300 t
Long-term potential yield (MSY):		
	Alaska	= 38,192 t
	Southeast region	= 10,771 t
	Central region	= 13,339 t
	Western region	= 14,082 t
Harvesting strategy	=	Escapement goals
Age/length at recruitment	=	3 yrs/55 cm
Age/length at 50% maturity	=	4-5 yrs/63-71 cm
Maximum age	=	6 yrs
Abundance and trend	=	Relatively stable
Importance of recreational fishery	=	Minor
Management	=	State and FMP
Status of exploitation	=	Fully exploited

Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

26. PINK SALMON

The pink salmon (*Oncorhynchus gorbuscha*) is often the "bread and butter" fish in many coastal communities because of their abundance in much of Alaska. Commercially important runs of this salmon occur in the southeast and central regions; Bristol Bay, in the western region, is the northern limit of large runs. This salmon is also popular with sport fisheries and it is important to subsistence users in Alaska.

The pink salmon is the smallest of the Pacific salmon in Alaska. Maturing salmon return to spawn in natal streams after 18 months in the ocean (2 years old). A female lays 1,500-2,000 eggs. Most spawning occurs in freshwater streams within a few miles of the coast and intertidal spawning is also common. The pink salmon is the only Pacific salmon having a fixed 2-year life span and salmon spawning in odd-numbered years are reproductively isolated from even-year spawning fish. Frequently, in a particular stream, one cycle will dominate over the other. In other streams, each cycle may have similar abundance. Soon after emergence, the young fry migrate to the ocean.



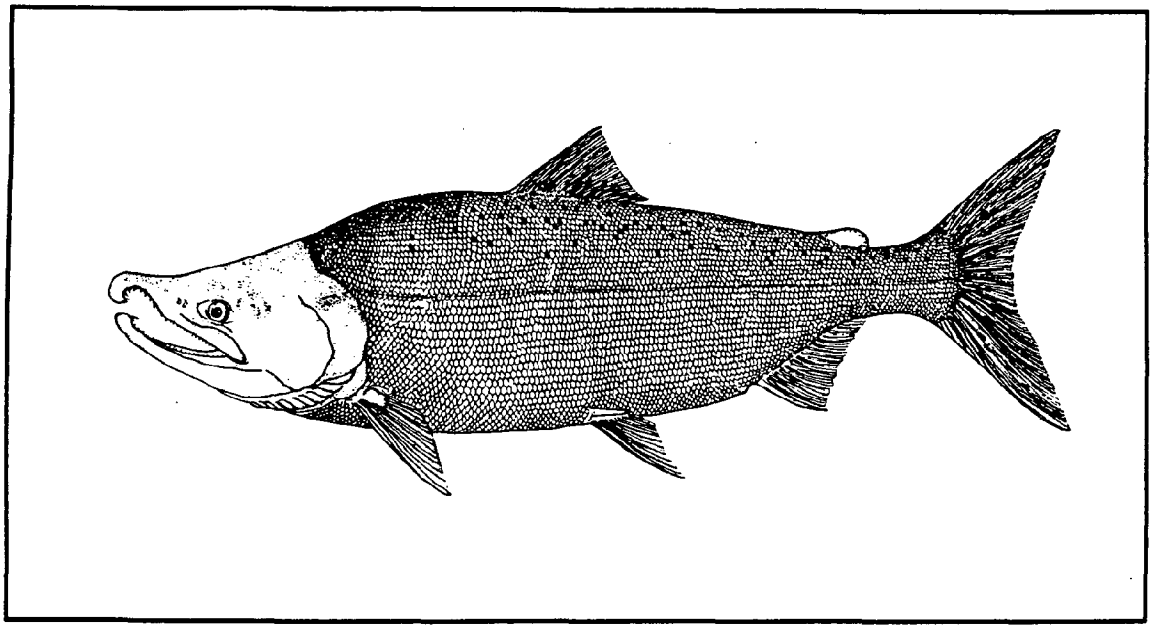
Most pink salmon are caught commercially in purse seines and gill nets. Historic records show that catches peaked in the 1930s and 1940s and then declined to low levels into the 1970s. Since 1975, the runs have been rebuilt through management efforts, hatchery production, and favorable ocean survival. Harvest levels peaked in 1991 at a record 128 million fish. In 1992, catches decreased to 60 million fish with reduced returns to several districts.

Hatchery production in Southeast and Central Alaska contributes significantly to the total catch. In the 1990-92 period, hatchery-produced pink salmon provided 24% of the catch. About 90% of the hatchery produced catch was from Prince William Sound.

On a statewide basis, pink salmon populations are fully utilized. Most stocks appear to have rebuilt to or beyond previous high levels as judged by catch data. Reasons for the unexpected low return in 1992 of wild and hatchery populations to Prince William Sound are not fully understood. Low survival of the 1990 year class may be linked to effects of low water temperatures on food abundance and fry growth and possible latent effects from the 1989 oil spill in the Sound. There is

PINK SALMON
Alaska
COMMERCIAL CATCH
(1,000s of fish)

Ten Year period	Average catch
1890-99	1,217
1900-09	8,338
1910-19	28,293
1920-29	36,118
1930-39	53,960
1940-49	49,129
1950-59	20,880
1960-69	29,840
1970-79	26,045
1980-89	68,730
1990-92	91,614



also concern that decreased spawning escapements in wild stocks may be due to interactions of hatchery releases and returns with wild fish.

PINK SALMON
Alaska

Average catch (1980-92):	Alaska	= 113,225 t
	Southeast region	= 48,610 t
	Central region	= 58,396 t
	Western region	= 6,218 t
Average catch (1990-92):	Alaska	= 127,284 t
	Southeast region	= 57,251 t
	Central region	= 68,413 t
	Western region	= 1,621 t
Long-term potential yield (MSY):		
	Alaska	= 113,225 t
	Southeast region	= 48,610 t
	Central region	= 58,396 t
	Western region	= 6,218 t
Harvesting strategy		= Escapement goals
Age/length at recruitment		= 2 years/50-61 cm
Age/length at 50% maturity		= 2 years/50-60 cm
Maximum age		= 2 years
Abundance and trend		= Stable
Importance of recreational fishery		= Major
Management		= State and FMP
Status of exploitation		= Fully exploited

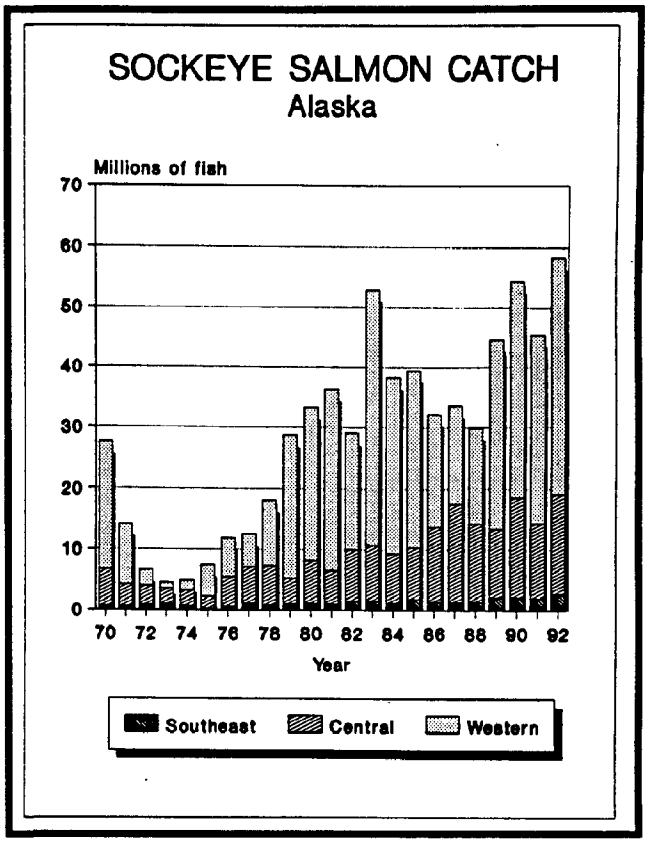
Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

27. SOCKEYE SALMON

The sockeye or red salmon (*Oncorhynchus nerka*) is Alaska's most valuable salmon. It occurs throughout much of Alaska and supports commercial fisheries in Bristol Bay and Central and Southeast Alaska.

Sockeye salmon spend from 2 to 4 years in the ocean. Spawning occurs generally in late summer and fall in freshwater rivers and lakes. The young fry normally spend from 1 to 2 years in lakes before migrating in the spring to the ocean. In some stocks, the fry stay in the rivers only and migrate to salt water before the first winter.

Most sockeye salmon are caught commercially in nearshore fisheries with gill nets and purse seines. Except for a small percentage of sockeye salmon caught in the EEZ, all fisheries occur in state waters and the resource is managed by the ADF&G. In Southeast Alaska, sockeye salmon fisheries near transboundary rivers and the U.S.-Canada border are managed in compliance with the Pacific Salmon Treaty between the United States and Canada. Sockeye salmon from British Columbia occur in varying numbers each year in Southeast Alaska waters where some are caught in U.S. fisheries.



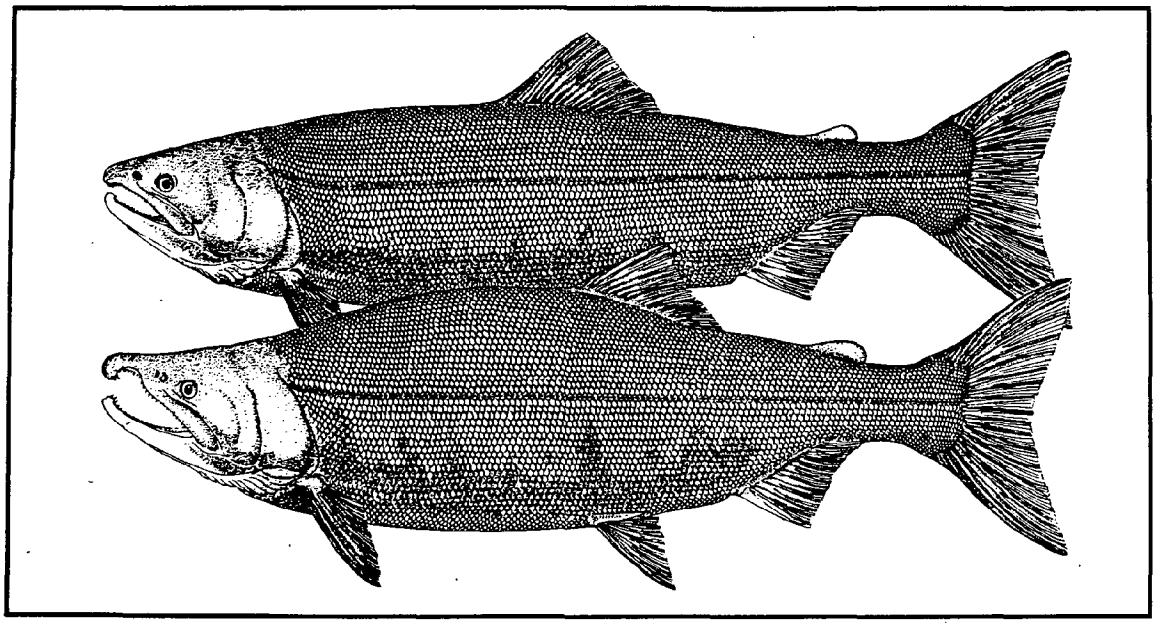
The area with the largest production of sockeye salmon is Bristol Bay in the western region. In recent years, about 60% of the total catch in the state has come from Bristol Bay.

Sockeye salmon catches were low in the mid-1970s, but subsequently increased and reached a high of 52.7 million fish in 1983 as stocks rebuilt. The 1992 catch of 58.3 million fish is an all-time record. The recent 1990-92 average catch was 52.0 million fish. Sockeye salmon from hatcheries and lake stockings are now a significant part of catches in some areas. Returns from enhancement projects in the southeast and central regions made up about 12% of the catch in 1992. From 1990 to 1992, the average contribution from enhancement to commercial catches was 20%. Much of the enhanced production is from returns to hatcheries in the Cook Inlet and Kodiak Island areas.

Stocks in the three regions are fully utilized. Most stocks appear to be rebuilt from previous low levels and are productive with recent yields at or above 13-year averages. Near-record catches in 1992 were recorded in Bristol Bay and off Kodiak Island

SOCKEYE SALMON
Alaska
COMMERCIAL CATCH
(1,000s of fish)

Ten Year period	Average catch
1890-99	7,479
1900-09	20,853
1910-19	26,826
1920-29	23,679
1930-39	25,321
1940-49	17,230
1950-59	10,990
1960-69	13,230
1970-79	13,626
1980-89	37,094
1990-92	52,021



while many other areas had above-average catches. One area with lower than average returns of wild stocks has been Prince William Sound.

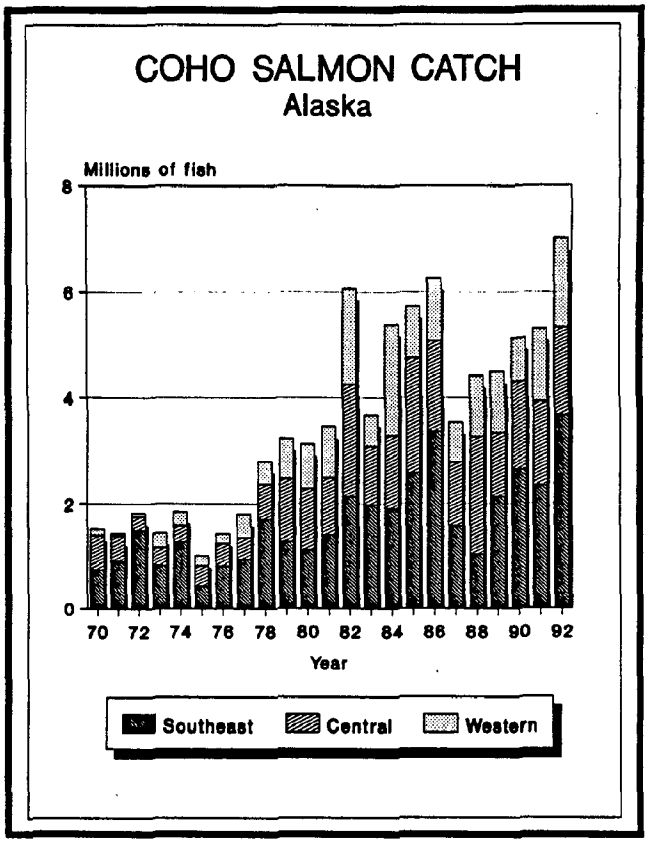
SOCKEYE SALMON
Alaska

Average catch (1980-92):	Alaska	= 109,025 t
	Southeast region	= 4,692 t
	Central region	= 30,731 t
	Western region	= 73,602 t
Average catch (1990-92):	Alaska	= 138,885 t
	Southeast region	= 6,348 t
	Central region	= 40,512 t
	Western region	= 92,025 t
Long-term potential yield (MSY):		
	Alaska	= 109,025 t
	Southeast region	= 4,692 t
	Central region	= 30,731 t
	Western region	= 73,602 t
Harvesting strategy		= Escapement goals
Age/length at recruitment		= 4 years/50 cm
Age/length at 50% maturity		= 5 years/60-70 cm
Maximum age		= 6 years
Abundance and trend		= Stable
Importance of recreational fishery		= Minor
Management		= State and FMP
Status of exploitation		= Fully exploited

Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

28. COHO SALMON

Coho salmon (*Oncorhynchus kisutch*), the third largest species of Pacific salmon, are found throughout Alaska. The species is most abundant in the central and southeast regions of the state. Maturing coho salmon enter fresh water from August through November to spawn in a myriad of small streams as well as large rivers. Spawning typically takes place in Alaska from late September through January when females deposit from 2,400 to 4,500 eggs. The juveniles spend one, two, or three winters in fresh water and then migrate to the ocean to spend about 18 months before returning to their freshwater stream of origin.



Troll and net fisheries for coho salmon in Alaska now land over 5 million fish annually. Coho salmon are also an important sport fish in marine and fresh water with about 300,000 fish taken each year. Catches have increased greatly since the mid-1970s. In 1975, the statewide harvest was about 1 million fish; since 1980, catches have ranged from 3.1 to 7.0 million fish. About 5% of the catch is currently from the EEZ troll fisheries. Management is conducted by the State of Alaska in nearshore waters and by the NMFS in the EEZ. Coho salmon from hatcheries and lake stockings made up about 14% of the 1990-1992 catch in the southeast and central regions. Since 1986, enhancement has produced 8-17% of the catches in the two regions.

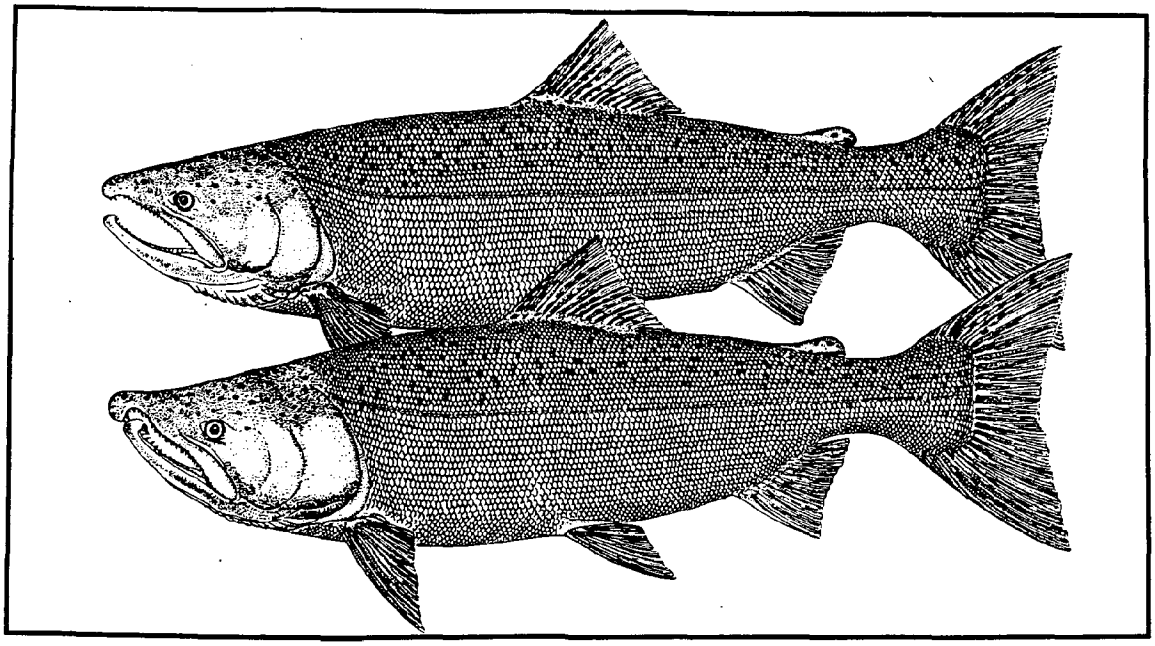
The status of coho salmon stocks in the state is apparently good when judged by recent catch levels. All stocks appear to be fully utilized and in most management areas, the stocks yield good catches. Status of stocks remains difficult to assess because it is difficult to identify individual populations in catches and virtually impossible to determine spawning escapements of coho salmon in the thousands of spawning areas.

There is concern that some stocks may have been impacted by foreign high-seas pelagic driftnet fishing in ocean areas where North American coho salmon mix with salmon from Asia. A 1992 United Nations resolution now bans pelagic high seas driftnet fishing, but illegal fishing continues in areas where North American salmon feed. The full impact of illegal high-seas fishing on coho salmon will be unknown until more information is obtained on stock identification, ocean distributions, and feeding areas.

Other activities may impact

COHO SALMON
Alaska
COMMERCIAL CATCH
(1,000s of fish)

Ten Year period	Average catch
1890-99	380
1900-09	659
1910-19	1,620
1920-29	2,120
1930-39	2,360
1940-49	3,099
1950-59	2,091
1960-69	1,856
1970-79	1,837
1980-89	4,595
1990-92	5,653



spawning and rearing habitat of coho salmon. Large areas of Alaska's wetlands are presently undisturbed and pristine and provide habitat critical to anadromous fishes. Concerns exist in some areas over loss of freshwater habitat. In the southeast region, logging in the Tongass National Forest and on state and native lands has impacted coho salmon habitat. Greater protection to salmon habitat is offered by recent legislation that requires that streamsides be protected and that buffer strips of standing timber be left along streams to protect spawning and rearing habitats.

COHO SALMON
Alaska

Average catch (1980-92):	Alaska	= 16,069 t
	Southeast region	= 6,679 t
	Central region	= 5,545 t
	Western region	= 3,844 t
Average catch (1990-92):	Alaska	= 17,829 t
	Southeast region	= 8,337 t
	Central region	= 5,501 t
	Western region	= 3,991 t
Long-term potential yield (MSY):		
	Alaska	= 16,069 t
	Southeast region	= 6,679 t
	Central region	= 5,545 t
	Western region	= 3,844 t
Harvesting strategy		= Historical catch
Age/length at recruitment		= 3 years/55 cm
Age/length at 50% maturity		= 4 years/74 cm
Maximum age		= 5 years
Abundance and trend		= Stable
Importance of recreational fishery		= Major
Management		= State and FMP
Status of exploitation		= Fully exploited

Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

29. CHINOOK SALMON

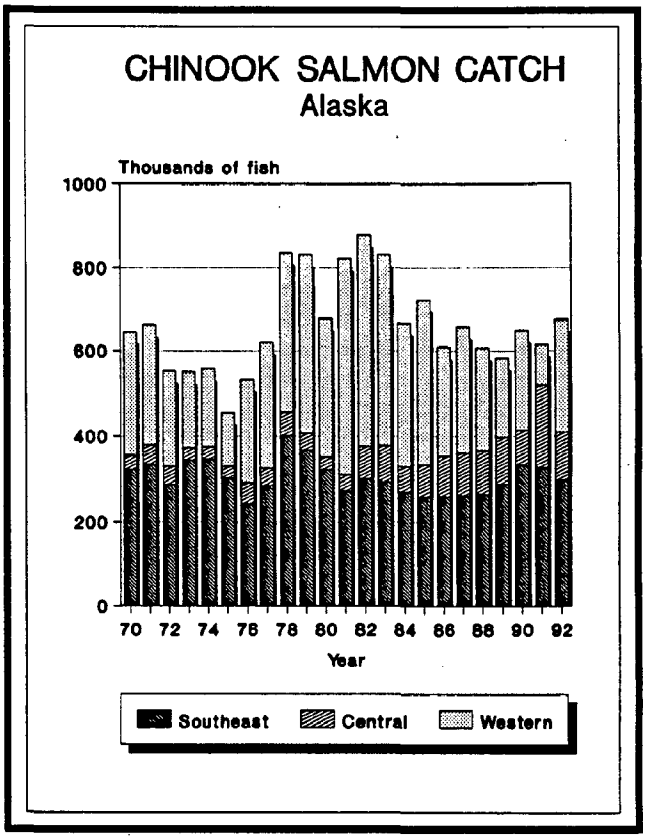
The chinook or king salmon (*Oncorhynchus tshawytscha*) is the largest of the Pacific salmon with some adults reaching a weight of 45 kg. Chinook salmon are found throughout most of Alaska. Major populations return to the Yukon, Kuskokwim, Nushagak, Susitna, Kenai, Copper, Alsek, Taku, and Stikine Rivers. Important runs also originate from numerous smaller rivers.

Alaska rivers normally have a single run of spawning chinook salmon which lasts from May through July. Adults return to fresh water after 2 to 5 years. Females deposit from 3,000 to 14,000 eggs which hatch in late winter or early spring. Most juvenile chinook salmon remain in fresh water until the spring following hatching and then migrate to the ocean.

Chinook salmon migrate long distances in the North Pacific Ocean. Salmon caught in the southeast and central regions of the Gulf of Alaska are from natural spawning and hatchery production facilities in Alaska, British Columbia, Washington, and Oregon. The many fisheries and stocks along the coast from the Pacific Northwest to Southeast Alaska are managed to rebuild stocks under terms of the Pacific Salmon Treaty. Recent data show that some indicator stocks of chinook salmon in the Treaty area are not responding to rebuilding efforts. Stocks of concern in Southeast Alaska include those in Behm Canal and the transboundary rivers.

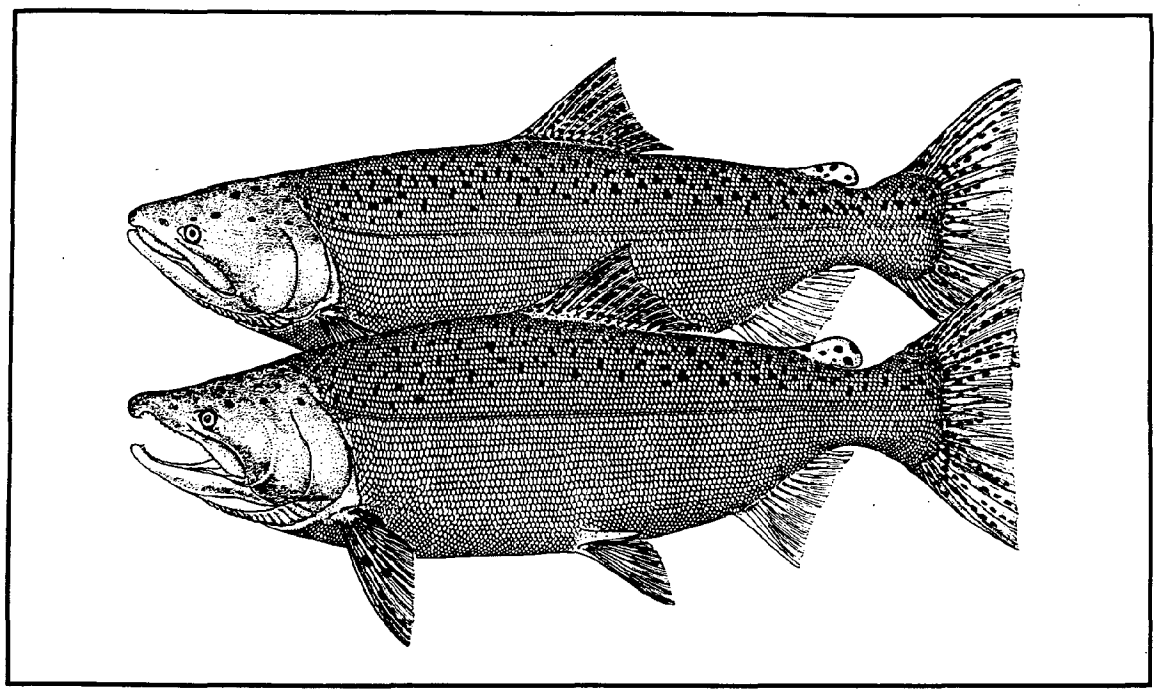
Most commercial catches are made by troll and gill-net fisheries on mixed stocks in nearshore areas. Total statewide catch has averaged about 684,000 fish annually between 1980 and 1992. This catch includes about 80,000 chinook salmon produced by hatcheries in Southeast and Central Alaska. The chinook salmon in Alaska is highly prized worldwide by sport fishers who travel to Alaska seeking wild area fishing experiences. About 134,000 chinook salmon are caught annually in the sport fisheries.

All stocks in Alaska are fully utilized. Management is directed at achieving escapement goals, reducing incidental harvests, and increasing production through enhancement. Recent decreases in harvests in the western region reflect weaker returns to Bristol Bay and the Lower Yukon River areas. In Bristol Bay, the



CHINOOK SALMON
Alaska
COMMERCIAL CATCH
(1,000s of fish)

Ten Year period	Average catch
1890-99	47
1900-09	207
1910-19	528
1920-29	738
1930-39	766
1940-49	654
1950-59	616
1960-69	556
1970-79	617
1980-89	694
1990-92	625



1991 return was below average for the sixth consecutive year.

Some Alaska stocks may have been reduced by foreign high-seas pelagic driftnet and trawl fishing. International agreements now restrict or limit high-seas fisheries in ocean areas where North American chinook salmon occur, but illegal fishing still remains a concern. High-seas catch data remain incomplete and more research is needed to establish baseline data so that Pacific salmon of North American and Asian origin can be identified and their ocean distribution determined. In U.S. groundfish fisheries, some chinook salmon are taken incidentally in the Bering Sea, Gulf of Alaska and off the Pacific Coast. The NPFMC continues to work with the U.S. industry to reduce chinook salmon bycatches.

For further information

Benton, D. 1990. Alaska and the fisheries of the North Pacific and Bering Sea. Alaska's Wildlife, ADF&G, 22(4):13-23.

Dahlberg, M. L. 1990. The high seas salmon fisheries of Japan, 1989. Alaska's Wildlife, ADF&G, 22(4):25-26, 40-41.

Eggers, D. M. [editor] 1989. Alaska commercial salmon catches, 1878-1988. Alaska Dep. of Fish and Game, Regional Info. Rep. No. 5J89-04, 69 p.

Geiger, H. J., and H. Savikko. 1991. Preliminary forecasts and projections for 1991 Alaska salmon fisheries and summary of the 1990 season. Alaska Dep. of Fish and Game, Regional Info. Rep. No. 5J91-01, 70 p.

Geiger, H. J., and H. Savikko. 1992. Preliminary forecasts and projections for 1992 Alaska salmon fisheries and review of the 1991 season. Alaska Dep. of Fish and Game, Regional Info. Rep. No. 5J92-05, 74 p.

Groot, C., and L. Margolis [editors]. 1991. Pacific salmon life histories. UBC Press, Vancouver, B.C., 564 p.

McNair, M., and J.S. Holland. 1993. FRED 1992 annual report to the Alaska State Legislature. Alaska Dep. of Fish and Game, Annual Rep. No. 127, 102 p.

McPhail, J. D., and C. C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fish. Res. Board Can., Bull. 173, 381 p.

Meehan, W.R. [editor]. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19, 51p.

North Pacific Fishery Management Council. 1990. Fishery management plan for the salmon fisheries in the EEZ off the coast of Alaska. N. Pac. Fish. Manag. Council, P. O. Box 1031316, Anchorage, Alaska 99510.

CHINOOK SALMON
Alaska

Average catch (1980-92):	Alaska	= 5,668 t
	Southeast region	= 2,031 t
	Central region	= 805 t
	Western region	= 2,832 t
Average catch (1990-92):	Alaska	= 4,830 t
	Southeast region	= 2,179 t
	Central region	= 750 t
	Western region	= 1,901 t
Long-term potential yield (MSY):		
	Alaska	= 5,668 t
	Southeast region	= 2,031 t
	Central region	= 805 t
	Western region	= 2,832 t

Harvesting strategy = Catch ceilings
Age/length at recruitment = 4 years/60 cm
Age/length at 50% maturity = 5-6 years/60-90 cm
Maximum age = 7 years
Abundance and trend = Relatively stable
Importance of recreational fishery = Major
Management = State, FMP, Prohibited species catch amount (Groundfish FMPs)
Status of exploitation = Fully exploited

Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

MARINE MAMMALS

By Howard W. Braham

Illustration: Katherine Zecca

This section of the report presents information on selected marine mammals off Alaska. Forty two species of marine mammals in U.S. waters of the North Pacific Ocean are under the jurisdiction of the Department of Commerce. This includes 31 species of whales, dolphins and porpoises, and 11 species of seals and sea lions. Most marine mammals make long-distance migrations or move hundreds of miles within smaller areas of the ocean between seasons of the year. Whales and dolphins often travel from one feeding ground to another or to spend the breeding season in lower latitudes and the major feeding and calf-rearing seasons in higher latitudes.

There are several populations of marine mammals that only spend a portion of the year in Alaska waters, such as humpback whales and northern fur seals, whereas others are found year-round in Alaska, such as the bowhead whale. These zoogeographic differences have led to varying life history strategies and result in the need to manage several populations or stocks rather than just one. Management of marine mammals is carried out under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973.

STATUS OF RESIDENT AND SELECTED SPECIES OF MARINE MAMMALS OFF ALASKA [1]
(e)=endangered; (t)=threatened; (d)=depleted

Species	Abundance (95% C.I.)	Trends (+/-%)	Method of Assessment	Assessment Coverage	Status and Authority
Bowhead whale	7,500 (6,400-9,200)	+3.1/yr (1978-88)	Ice-based counts	Complete	Below OSP ESA (e)
Gray whale	20,869 (19,200-22,700)	+3.3%/yr (1968-88)	Land-based counts	Complete	Recovered ESA (e)
Humpback whales	>2,000	Unknown	Photographic mark-recap.	Partial	Below OSP ESA (e)
Killer whale	>300	Unknown	Individual counts	Partial	Uncertain MMPA
Beluga	15,800-18,450	Unknown	Aerial and land-counts	Partial	Uncertain MMPA
Dall's porpoise	300,000-600,000	Unknown	Line transect	Partial	Uncertain MMPA
Harbor porpoise	Unknown	Unknown	--	--	Uncertain MMPA
Northern sea lion	>34,844	-70% (1970-90)	Counts on shore	Complete	Below OSP ESA (t)
Northern fur seal	982,000	-50% (1975-90)	Land-counts Pribilof Is.	Complete	Below OSP MMPA (d)
Harbor seal	Uncertain (<100,000)	-60% (1976-92)	Land-counts Tugidak Is.	Partial	Below OSP MMPA
Spotted[2] seal	Unknown	Unknown	Ice-counts and land counts	Partial	Uncertain

[1] Bowhead, gray and humpback whale estimates are for the entire eastern North Pacific Ocean; all others are for Alaska.
[2] Other ice-associated seals are the bearded, ribbon, and ringed seals.

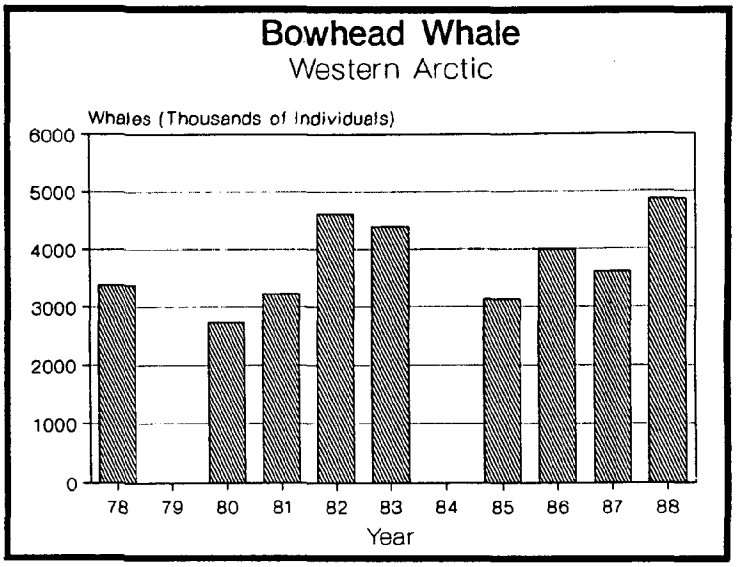
Both Acts require that management of marine mammals be based on the identification and enumeration of populations or stocks.

A summary of the status, impact of incidental take, and desciption of selected stocks is described in the following chapters.

Incidental Take of Selected Marine Mammals In Domestic Fisheries off Alaska

Species	Incidental Take	Fishery (others)	10-year Trend	Impact of Exploitation
Gray whale	Unknown	Coastal set-nets	Unknown	Unchanged
Killer whale	Unknown	Long-line and gill-nets	Unknown	Unknown
Beluga whale	Unknown	Coastal gill-nets	Increasing?	Unknown
Dall's porpoise	Unknown	Coastal gill-nets	Unknown	Unknown
Harbor porpoise	Unknown	Coastal gill-nets	Unknown	Unknown
Northern sea lion	1,023/yr (1978-85) <100/yr (1988-92)	Coastal gill-nets and trawls	Decreasing	Unknown
Northern fur seal	Three (1990)	Coastal gill-nets and trawls	Decreasing	Unknown
Harbor seal	Unknown	Coastal gill-nets and trawls	Unknown	Unknown
Spotted seal	Unknown	Unknown	Unknown	Unknown

30. BOWHEAD WHALE



The bowhead whale (*Balaena mysticetus*) also known as Agvik by Alaskan Eskimos, is the only large cetacean associated with the Arctic pack-ice year round. The species is endemic to the Northern Hemisphere with three stocks in the North Atlantic Ocean (East Greenland-Spitsbergen, Baffin Bay-Davis St., and Hudson Bay-Foxe Basin) and two stocks in the North Pacific (Okhotsk Sea and western North American Arctic).

The migration of bowheads in western Arctic Alaska takes place from late March through June from the western Bering Sea (Russia) into the Beaufort Sea (U.S. and Canada). Some remain in the Chukchi Sea during summer. The autumn migration precedes the advancing pack-ice from September to December.

Calves are born from March to July, following a 13-month gestation period. Pregnancy rates vary from 0.15 to 0.33; the calving interval is 4-5 years. Length at birth is 4-5m, 8-9m at age 1, and 13-14m at sexual maturity (females). Age at first reproduction is thought to range from 9 to 15 years. Annual calf production varies from 3% to 12%, possibly reflecting an unstable or highly variable ecosystem. Euphausiids and copepods are the principal prey, but epibenthic fauna are also taken.

Bowhead whales were one of the most severely exploited cetaceans in the history of commercial whaling. The world abundance prior to commercial whaling probably exceeded 120,000, but at its lowest point, near the beginning of the 20th century, the species totaled no more than a few thousand. In the western North American Arctic, 18,650 bowheads were killed by Yankee whalers between 1848 and 1914 -- this from a population of probably less than 18,000-20,000 animals; over 60% of the whales were killed between 1850 and 1870. Alaskan Eskimos (Inuit) have used bowhead whales for subsistence for several thousand years. This century the take of bowheads at U.S. coastal Inuit villages averaged 20 whales killed per year from 1920 to 1969, about 40 per year from 1970 to 1977, and 22 per year between 1978 and 1990. A quota system administered by the Alaskan Eskimo Whaling Commission and the NMFS was initiated in 1978 by agreement with the International Whaling Commission.

The present estimate of abundance of the western Arctic stock is 7,500 (95% C.I., 6,400-9,200) based on a combined analysis of ice-based observer counts and passive acoustics data collected off Point Barrow, Alaska, during the bowhead's spring migration. Changes in estimates of abundance since census studies began in 1978 reflect improvements in the methods of data collection and analysis, and in an actual increase in the number of whales. Since 1978, this bowhead stock has increased 3.1% (95% C.I., 0.1-6.2) per year based on counts of whales adjusted for periods of no-watch and bad weather. Additional simulations also show that the stock has increased since 1920, just after commercial whaling ended. The present size of the stock is about 40.9% (95% C.I., 38-42) of its initial size (in 1848) based on simulation and sensitivity tests of historic data. These data suggest that the western Arctic stock of bowheads is recovering from commercial whaling and that it is below the population size supportable by the ecosystem (i.e., its carrying capacity).

Critical habitat may include the spring open lead system from the Bering Strait to the Beaufort Sea, the nearshore Beaufort Sea in autumn for feeding and migration, and polynya and other open-water areas within the Bering Sea pack-ice used by bowheads to overwinter.

For further information

Bockstoce, J. R. 1986. Whales, ice, and men. The history of whaling in the western Arctic. Univ. Washington Press, Seattle, WA. 400p.

Braham, H. W. 1989. Eskimos, Yankees, and bowheads. Oceanus 32(1):54-62.

Breiwick, J. M., L. L. Eberhardt, and H. W. Braham. 1984. Population dynamics of western arctic bowhead whales (*Balaena mysticetus*). Can. J. Fish. Aquatic Sci. 41: 484-496.

Krogman, B., D. Rugh, R. Sonntag, J. Zeh, and D. Ko. 1989. Ice-based census of bowhead whales migrating past Point Barrow, Alaska 1978-83. Mar. Mammal Sci. 5: 116-138.

Nerini, M. K., H. W. Braham, W. M. Marquette, and D. J. Rugh. 1984. Life history of the bowhead whale, *Balaena mysticetus* (Mammalia: Cetacea). J. Zool. (London) 204: 443-468.

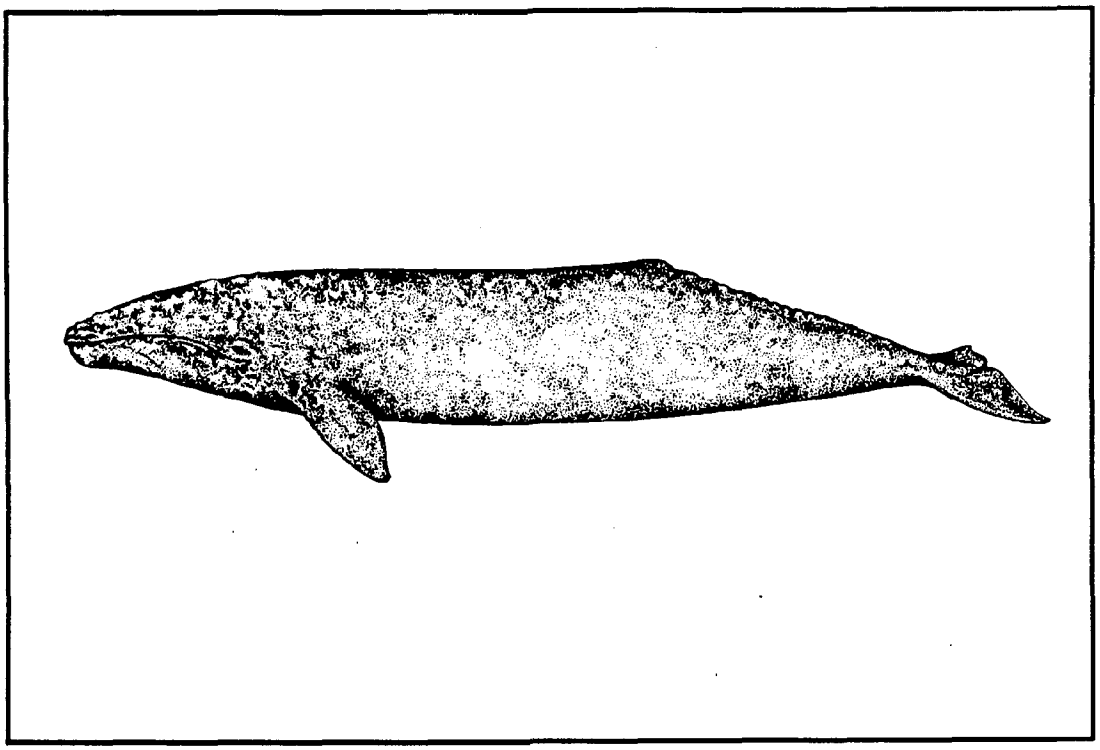
Zeh, J. E., J. C. George, A. E. Raftery, and G. M. Carroll. 1991. Rate of increase, 1978-1988, of bowhead whales, *Balaena mysticetus*, estimated form ice-based census data. Mar. Mammal Sci. 7: 105-122.

Take of Bowhead Whales by Alaskan Eskimos, 1978-1990

Year	Quota	Fate of Whales: Struck	Landed	Killed[1]
1978	20	18	12	16
1979	27	27	12	23
1980	26	34	16	29
1981	32	28	17	26
1982	19	19	8	13
1983	18	18	10	16
1984	25	25	12	22
1985	18	17	11	13
1986	32	28	20	23
1987	32	31	22	29
1988	35	28	15	28
1989	44	26	18	18+
1990	44	44	30	30+

[1] An estimate of the fate of whales struck and lost is reported to NMFS by the Alaskan Eskimo Whaling Commission; a "+" means that the number killed, beyond the number landed, is unknown.

31. GRAY WHALE



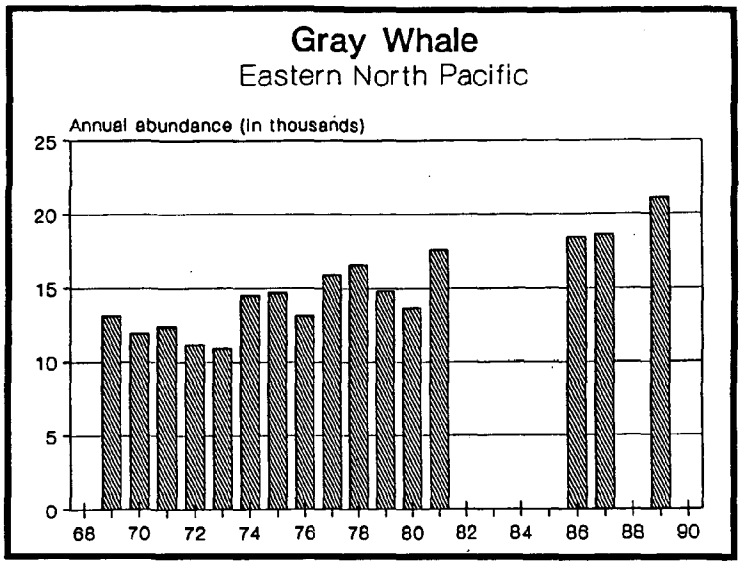
There are two stocks of gray whales (*Eschrichtius robustus)* endemic to the North Pacific Ocean. One stock is located in the eastern North Pacific Ocean, the stock migrates between the western Arctic Ocean (off the U.S., Canada, and Russia coasts) to waters off Baja California. The second stock migrates from the Okhotsk Sea along the coast of Russia, Japan, Republic of China, and the Republic of Korea. The eastern North Pacific or "California" stock was heavily exploited, principally by Yankee commercial whalers during the second half of the 19th century, and may have been reduced to only a small fraction of its pre-exploitation population size.

Gray whales in the eastern North Pacific Ocean are distributed across much of the southern Chukchi and northern Bering Seas where they feed from May to November. They migrate out of the Bering Sea by December. Southward migrating gray whales are found along the west coast of North America from November to February with the majority of the whales passing central California from early December to early February. There is some overlap with the first of the northward migrants from Baja California with the tail-end of the migration moving south. A small number of whales do not undertake a full migration and spend the winter in waters south of Alaska.

Gray whales are generally dark gray to black in color with mottled patches of white generally formed from the sloughing of ectoparasitic barnacles such as *Cyamus scammoni*. As with other baleen whales, adult female gray whales reach sexual maturity at slightly greater lengths (12.95 m, standard error (SE) = 0.11) than do males (12.43 m, SE = 0.12), with maximum physical maturity reached at approximately 14.0 m in females and 13.0 m in males at perhaps 40 years of age. Mean birth length is 4.6 m (both sexes), 7-8 m at weaning (usually 6-8 months postpartum) and at 1 year the young animal is 8 m or greater. Age at sexual maturity is 9 years (range 6-12 years) for females and 6 years (range 5-9 years) for males. Mean conception date is 5 December; mean birth date is 27 January; and

gestation lasts 418 days, on average. With an ovulation rate of 0.50/year and a pregnancy rate of 0.46/year, an adult female gray whale gives birth about every 2 years. Estimated survival rates range from 95% for adults to 89% for juveniles.

The present size of the eastern North Pacific stock of gray whales is 20,869 (19,200-22,700). This level is equal to or larger than the size of the population in 1846, estimated to have been 15,000-20,000. The population has been increasing at a rate of 3.3% per year (SE = 0.5%) since 1968, during which a subsistence catch of 167 whales per year (SE = 3.5) took place by the Soviet Union.



For further information

Braham, H. W. 1984. Distribution and migration of gray whales in Alaska, p. 249-266. In M.L. Jones, S. L. Swartz, and S. Leatherwood (eds.), The Gray whale, *Eschrichtius robustus*. Orlando, FL. Academic Press, Inc.

Braham, H. W., and G. P. Donovan (eds.). In press. The comprehensive assessment of gray whales, *Eschrichtius robustus*. Cambridge, U.K., International Whaling Commission (Special Issue 14).

Reilly, S. B., D. W. Rice and A. A. Wolman. 1983. Population assessment of the gray whale, *Eschrichtius robustus*, from California shore censuses, 1967-1980. Fish. Bull., U.S. 81: 267-281.

Rice, D. W., and A. A. Wolman. 1971. The life history of the gray whale *Eschrichtius robustus*. Special Publication, Amer. Soc. Mammal. 3: 1-142.

Rugh, D., R. Ferrero, and M. Dahlheim. 1990. Interobserver count discrepancies in a shore-based census of gray whales. Mar. Mammal Sci. 6(2): 109-120.

32. HUMPBACK WHALE

Photo: AFSC

Humpback whales (*Megaptera novaeangliae*) occur in all oceans of the world. Like most baleen whales, humpbacks annually migrate to high-latitude, summer feeding grounds from temperate or sub-tropical wintering grounds. The North Pacific humpback whale population tentatively has been divided into three stocks, based on the relative discreetness of wintering areas: 1) the Mexican stock, 2) the Hawaiian stock, and 3) the Asian stock (near the Bonin and Ryukyu Islands, Japan). Some exchange takes place between the Mexican and Hawaiian stocks, which can be found in summer in California, southeast Alaska, and the Gulf of Alaska. The wintering grounds of humpbacks seen in the Bering and Chukchi seas is unknown, although a small number of whales tagged in the western North Pacific Ocean south of Japan in the 1950s and 1960s were recovered near the eastern Aleutian Islands a few years after tagging.

Humpbacks primarily inhabit Alaska waters from late spring to early winter, approximately May through December. Peak numbers of whales off Southeast Alaska typically occur in late August and September. Individual humpbacks may be seen in Alaska at any time of year, especially in Southeast Alaska, but there is no evidence to suggest that any of those individuals regularly overwinter there. Short-term seasonal distribution patterns have been documented in Southeast Alaska and in Prince William Sound, including fairly predictable local movements, such as those among favored feeding areas. Seasonal distribution of humpbacks on the feeding grounds is subject to annual variability due to changes in oceanographic conditions and the distribution and availability of prey.

The pre-exploitation (prior to 1905) population size of humpback whales in the North Pacific Ocean (western and eastern stocks) is not known, but estimates suggest that it may have been on the order of 15,000 whales. There has been no sequence of surveys long enough or consistent enough to detect trends in abundance.

Current estimates of population size range from about 1,200 to over 2,000. More than 1,000 whales have been identified in Hawaii (between 1977 and 1982). Mark-recapture analyses based on photo-identification data suggest that 1,600 - 2,100 whales annually visited Hawaiian waters (during the 1970s

and 1980s). No good estimates are available for the number of whales on the other wintering grounds in Mexico or the western Pacific. Preliminary work suggests there may be only a few hundred humpbacks outside the main Hawaiian breeding grounds. The current best estimate for the eastern North Pacific stock(s) is 1,398-2,040. This population size is only 8%-13% of its estimated initial size of 15,000 in the North Pacific in 1850 prior to commercial whaling.

An estimated 300 to 350 humpbacks are present in Southeast Alaska during summer and fall. Aerial and shipboard survey data have been used to estimate that about 400 humpbacks summer in the Gulf of Alaska and Prince William Sound and another 300 to 350 may summer near the Shumagin and Semidi Islands, Alaska. The number of humpbacks near the eastern Aleutian Islands is unknown but presumably small. Less than 100 sightings of humpback whales have been made in the Bering Sea since 1975.

There are few reported fishery interactions with humpback whales, such as incidental take, in Alaska. Three humpbacks were reported to be entangled in seine nets in Prince William Sound in the early 1980s. Typically two or three humpbacks are reported entangled each year in gill nets and buoy lines in Southeast Alaska and British Columbia. In the summer of 1987 at least seven humpbacks were reported entangled in gill nets in Southeast Alaska; only one whale died. No estimates are available for the extent of unreported incidental take, nor are estimates available for the incidental take of humpbacks by commercial fisheries in other areas of Alaska.

For further information

Baker, C. S., S. R. Palumbi, H. Lambertson, M. S. Weinrich, J. Calambokidis, and S. J. O'Brien. 1990. Influence of seasonal migration on the geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344:238-240.

Baker, C. S., and L. M. Herman. 1987. Alternative population estimates of humpback whales (*Megaptera novaeangliae*) in Hawaiian waters. Can. J. Zool. 65: 2818-2821.

Baker, C. S., L. M. Herman, A. Perry, W. S. Lawton, J. M. Straley, and J. H. Straley. 1985. Population characteristics and migration of summer and late-season humpback whales (*Megaptera novaeangliae*) in southeastern Alaska. Mar. Mammal Sci. 1: 304-323.

Hammond, P. S., S. A. Mizroch, and G. P. Donovan (editors). 1990. Individual recognition of cetaceans: Use of photo identification and other techniques to estimate population parameters. Cambridge, U.K., Int. Whaling Comm. (Special Issue 12), 440 p.

Humpback Whale Recovery Team. 1990. National recovery plan for the humpback whale (*Megaptera novaeangliae*) in waters of the United States of America. U.S. Department of Commerce, NOAA, NMFS, Washington, D.C., 82 p. (Available through the Office of Protected Resources, NMFS, NOAA, 1335 East-West Highway, Silver Spring, MD 20910.)

33. KILLER WHALE

The killer whale (*Orcinus orca*) is the largest member of the dolphin family Delphinidae. The large size, distinct dorsal fin, contrasting white and black coloring, robust body, postocular white patch, and ovate flippers are diagnostics. Adults range in length from 5 to 9 m. Dorsal fin height can be 1.8 m in adult males and up to 0.9 m in adult females and sub-adult males. The genus *Orcinus* is considered monotypic with geographical variation noted in size and coloring. Differences in call repertoires and overlapping color patterns indicate some isolation among pods. Chromosomal and biochemical evidence suggests that certain pods may be genetically distinct.

Killer whales have been observed in all oceans and seas of the world and, although reported from tropical and off-shore waters, they prefer the colder waters typically within 800 km of major continents. In Alaskan waters, they concentrate near land masses and continental shelf waters and are found in greatest numbers in Southeast Alaska, Prince William Sound, near Kodiak Island, and in the southeastern Bering Sea. They also have been seen as far north as the Arctic Ocean.

Killer whales typically occur in small pods of fewer than 40 animals. Multi-pod gatherings have been noted, however, the biological significance of these groupings is not known. Pod composition appears to remain constant for many years with little intermixing of individuals among pods. At least two major types of pods have been noted. Transient pods move in and out of areas typically occupied by resident pods of killer whales, but have no defined "home range." Resident pods are usually found in one area year-round (encompassing several hundred to several thousand square miles), and are dominated by strong matriarchal lineages. The natural mortality rate of killer whales is estimated to be less than 5% per year, and may be as low as 1% per year, suggesting that killer whales form stable and long lasting family units.

Movements of killer whales are believed to be related to the availability of prey, such as spawning Pacific salmon, and the movements of seals and whales. Killer whales prey on cod, herring, flatfish, sablefish, and other fish. Resident pods typically prey on fish, and transient pods possibly favor marine mammals as prey. Killer whales have never been subjected to significant rates of exploitation and are not taken for subsistence. Incidental takes during fishing operations are rare. Significant fishery interactions have been documented between killer whales and sablefish in the Bering Sea and Prince William Sound. Between 1985 and 1987, 7 killer whales from a resident pod of 35 were observed taking sablefish off fisherman's longlines. The seven were later reported missing and are presumed to be dead. Fishermen sometimes shoot at killer whales and use seal bombs and other explosives to keep the whales away from their catch. There is no estimate of abundance of killer whales in Alaska. The total population size is probably not large, based on anecdotal accounts during surveys for other species. The total estimate of abundance for Prince William Sound, Shelikof Strait and Southeast Alaska is 286. Population estimates are not available for the western Gulf of Alaska, Aleutian Islands, or Bering Sea and north.

For further information

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whaling Comm. 32: 643-646.

Dahlheim, M. E. 1981. A review of the biology and exploitation of the killer whale, *Orcinus orca*, with comments on recent sightings from Antarctica. Rep. Int. Whaling Comm. 31: 541-456.

Dahlheim, M. E. 1988. Killer whale (*Orcinus orca*) predation of longline catches of sablefish (*Anoplopoma fimbria*) in Alaskan waters. NWAFC Processed Rep. 88-14, 31 p. Alaska Fish. Sc. Cent., Nal. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Dahlheim, M. E., and J. Heyning. In press. The killer whale. In S. Ridgway and R. Harrison (eds.), Handbook of Marine Mammals. New York, NY, Academic Press.

34. BELUGA WHALE

In western North America, beluga whales (*Delphinapterus leucas*), also known as belukha or white whales, are located in coastal waters of Alaska from the eastern Gulf of Alaska near Yakutat Bay north into the Beaufort Sea. Based on the potential for geographic isolation as a result of differential seasonal movements versus year-round residency, there are possibly four (summer) stocks. The stocks are located in 1) Cook Inlet (north Gulf of Alaska); 2) Bristol/Kuskokwim Bays and Norton Sound/ Yukon Delta (Bering Sea); 3) Kotzebue Sound and west coast of the Chukchi Sea; and 4) the eastern Beaufort Sea.

North of lat. 60° N, belugas are closely associated with open leads and polynya in ice-covered regions. Concentrations occur in both offshore and coastal areas, which vary by season and region. Factors affecting seasonal and daily distribution include extent of ice cover, prey availability, tidal conditions, and human disturbance. Generally, beluga whales occupy waters associated with offshore pack-ice in winter, and migrate in spring to warmer (10°-15°C) coastal estuaries, bays, and rivers to molt and to rear calves. Most of the North American population in Alaska waters is associated with the offshore winter areas, although year-round concentrations occur in the Bering Strait, the southern Chukchi Sea, Bristol Bay, and in Cook Inlet.

The duration of residence in summer coastal areas varies from a few days to several months, and most belugas usually remain in densely concentrated groups throughout summer. Migration to coastal areas coincides with the break-up of ice and the arrival of spawning fish such as Arctic cod (*Boregadus saida*), smelt, herring, capelin (*Mallotus villosus*), and Pacific salmon. Belugas make use of tides in pursuit of prey by ascending rivers on the flood and descending with ebb tides; a few have been sighted 1,000 km up the Yukon River.

Calving occurs from about March to September and peaks in mid-summer. Age at sexual maturity in females is 4-7 years (based on two growth layers in the teeth for estimating age) and 5-8 years for males. The calving intervals are generally every 3 years, but about 25% calve every other year. Birth rate tapers off with age from a peak of about 0.333 at age 11-22 to 0.125 at age 29-38. The average life span is about 30 years, but older animals up to 40 years have been found in the wild. Gestation is presumed to last 14-15 months, although delayed implantation cannot be ruled out. Lactation can vary from 12 to 32 months, but appears to last on average between 1 and 2 years.

The minimum estimated total population in Alaska waters is 15,800 to 18,450 including about 400-500 in the Gulf of Alaska-Cook Inlet. Some estimates are as high as 30,000 to account for animals offshore or not observed during past surveys. Beluga whales are taken incidentally in commercial and native coastal fisheries in Alaska and for subsistence. Most incidental kills occur in Bristol Bay where a large salmon fishery exists. In 1983, 27-31 belugas were found dead in Bristol Bay and 12 were caught in salmon gill nets. Up to five belugas per year have been reported taken in the salmon gillnet fishery in Cook Inlet.

Only indigenous people are allowed to hunt belugas. Subsistence takes occur in western Alaska (especially in the northern Bering Sea and Chukchi Sea), along the Russian Far East of Chukotka, and in the western Canadian Arctic Ocean (eastern Beaufort Sea). The estimated total kill (landed, stuck,or lost) in U.S. waters and the Canadian Beaufort Sea exceeds more than 800 per year (based on data from the 1970s and 1980s), although the precise annual total is unknown. These animals probably come from the same population that winters in the Soviet and U.S. Bering Sea. The actual number of animals killed each year is not known because most of the villages are not monitored, and the fraction of whales that die after being stuck is also unknown. The number of belugas incidentally killed and harvested is probably not great enough to affect the total population, but the affect on local stocks is unknown (800 is 5% of the minimum total population estimate of 15,800).

For further information

Braham, H. W., B. D. Krogman, and G. Carroll. 1984. Bowhead whale and white whale migration, distribution, and abundance in the Bering, Chukchi and Beaufort Seas, 1975-1978. NOAA Tech. Rep., NMFS SSRF-778, 39 p.

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. In J. Lentfer. (ed.)., Selected marine mammals of Alaska. Species accounts with research and management recommendations. Mar. Mammal Comm., 1825 Connecticut Ave NW, Room 512, Washington, D.C. 20009.

35. DALL'S PORPOISE

Dall's porpoise (*Phocoenoides dalli*) are widely distributed across the entire subarctic North Pacific Ocean. Four color morphs of the same species have been identified. The *P. dalli truei* morph, common along the Pacific coast of Japan, is black with a white flank patch extending forward as far as the flippers, and a white throat patch. The *P. dalli dalli* morph is more cosmopolitan throughout the species' range; the white flank patch does not extend forward beyond the dorsal fin, and there is no white throat patch. The third morph, which is uncommon, is a solid black form occurring along the Sanriku coast of Japan and in the northwestern Pacific. Dall's porpoise occur predominantly offshore but may be inshore in some areas; the southern extent of their range is approximately lat. 28°N, which coincides with the 17°-18° C isotherm. The northern limit is generally Cape Navarin, U.S.S.R., in the western Bering Sea (lat. 62°N), although there are a few recorded sightings off northwest Alaska (i.e., Chukchi and Beaufort Seas). Three populations or stocks are postulated for the western North Pacific and adjacent areas: the *truei* morph off the Sanriku coast as far east as long. 180°; the *dalli* morph between Japan and the Aleutian Islands; and the *dalli* morph in the Okhotsk Sea. Stock separation has also been hypothesized for the eastern North Pacific, but specific areas have not been proposed. The reproductive cycles of animals in the Bering Sea and western North Pacific are apparently out of phase, further supporting the stock separation hypothesis.

Throughout most of the eastern North Pacific, Dall's porpoise are present during all months of the year, although there may be seasonal inshore-offshore and north-south movements in Alaska, such as out of Prince William Sound and areas in the Gulf of Alaska and Bering Sea. Based on studies carried out between 1978 and 1992, the minimum estimated abundance of Dall's porpoise in the Bering Sea, Aleutian Islands, and Gulf of Alaska is 417,000 (95% CI : 316,000-575,000) but does not include Southeast Alaska .

The Japanese high-seas salmon mothership fishery has been operating in the North Pacific since 1952. The estimated annual incidental take by the Japanese in this fishery (1981-87) within the U.S. EEZ ranged from 741 (1987) to 4,187 (1982). The mean take rate for observed salmon gill-net operations from 1981 to 1985 was 0.47 porpoise per set (15 km of net) inside the EEZ. The estimated incidental catch outside the EEZ ranged from 479 to 1,716. These fisheries no longer operate in U.S. waters and are not monitored by U.S. observers outside the EEZ.

Incidental take by the Japanese squid fishery were reported by the Fisheries Agency of Japan to be 2,500 in 1982, 2,502 in 1983, and 2,515 in 1984. The observed take in 1989 was 141 Dall's porpoise, but this was based on monitoring only 4%-10% of the fishing effort by the fleet. The impact of commercial fishing on Dall's porpoise is unknown.

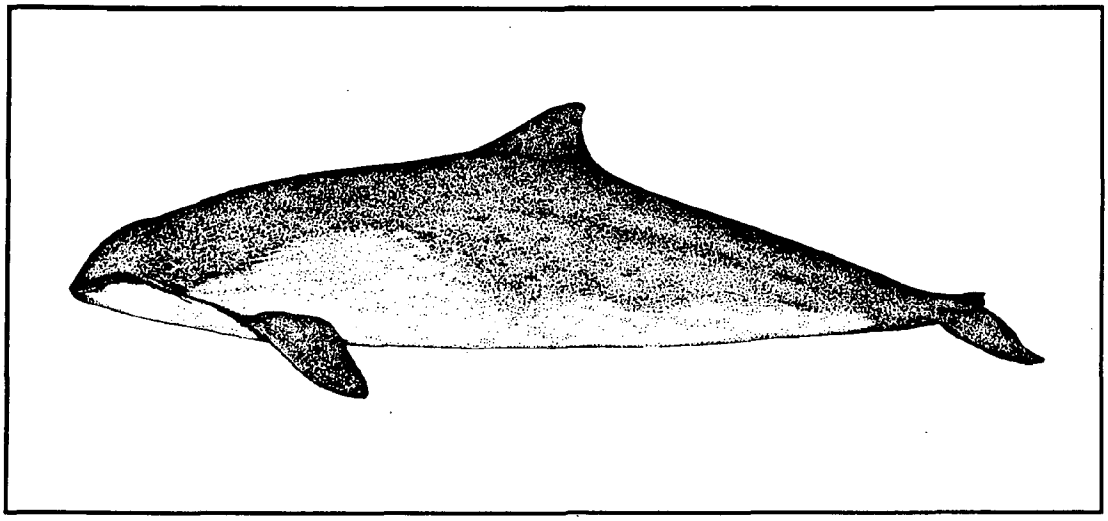
For further information

Kasuya, T., and L. L. Jones. 1984. Behavior and segregation of the Dall's porpoise in the northwestern North Pacific Ocean. Sci. Rep. Whales Res. Inst., Tokyo 35: 107-128.

Kasuya, T., and S. Shiraga. 1985. Growth of Dall's porpoise in the western North Pacific and suggested geographic growth differentiation. Sci. Rep. Whales Res. Inst., Tokyo 36: 139-152.

Winans, G., and L. L. Jones. 1988. Electrophoretic variability in Dall's porpoise (*Phocoenoides dalli*) in the North Pacific Ocean and Bering Sea. J. Mammal. 69: 14-21.

36.HARBOR PORPOISE



Harbor porpoise (*Phocoena phocoena)* in the eastern North Pacific Ocean range from the Beaufort Sea, Alaska, to Point Conception, California, although records of harbor porpoise from Los Angeles Harbor also exist. The smallest of the North Pacific porpoises, *Phocoena* is less than 6 ft long, dark grey on top and light-colored underneath and has a proportionally large triangular dorsal fin. Female harbor porpoise reach maturity at 3 years of age and probably reproduce annually. Gestation lasts 11 months. Maximum age is perhaps around 15 years. Harbor porpoise feed on schooling fish, such as herring and capelin, but also euphausiids and squid.

The total number of harbor porpoise in Alaska is unknown. Some systematic surveys in Alaska for other cetaceans have frequently included harbor porpoise sightings. A seasonal peak of over 500 animals in Prince William Sound was estimated in the late 1970s. Densities of harbor porpoise in the eastern Bering Sea were estimated in the mid-1980s at 13 animals per 1,000 nmi^2. Three geographic stock units have been proposed for Alaska: the northern Bering Sea and adjacent Arctic waters; the Aleutian Islands and southern Bering Sea; and the Gulf of Alaska and Southeast Alaska. These divisions are not confirmed but are suggested based on oceanographic conditions and topography of the area which might limit the movements of harbor porpoise.

Insufficient information is available on abundance and incidental mortality to make an assessment of the status of harbor porpoise populations in Alaska. A single incidental capture from the Bering Sea was reported in 1982, and 11 animals were reported taken from Bering Sea during high-seas gillnet salmon fisheries between 1978 and 1987. The only documented study of incidental take of harbor porpoise is from the Copper River Delta where 102 *Phocoena* were reported entangled in 1978 of which 44 were released alive.

For further information

Gaskin, D. E. 1983. The harbor porpoise: Regional populations, status and information on direct and indirect catches. Rep. Int. Whaling Comm. 34: 569-86.

Matkin, C. O., and F. H. Fay. 1980. Marine mammal-fishery interactions on the Copper River and in Prince William Sound, Alaska, 1978. Mar. Mammal Comm. Rep., MMC-78/70. (Available through NTIS, Springfield VA, as PB 80-159536.)

Taylor, B. L., and P. K. Dawson. 1984. Seasonal changes in density and behavior of harbor porpoise (*Phocoena phocoena*) affecting census methodology in Glacier Bay National Park, Alaska. Rep. Int. Whaling Comm. 34: 479-483.

Yurick, D. B. 1977. Populations, sub-populations, and zoogeography of the harbor porpoise, *Phocoena phocoena* (L.). M. S. Thesis. University of Guelph. Guelph, Ontario, Canada. 148 p.

37. NORTHERN SEA LION

Photo: Richard Merrick

The northern sea lion (*Eumetopias jubatus*), also known as the Steller sea lion, is endemic to the North Pacific Ocean. Its range is from the Kuril Islands, Russia, to California, north to lat. 63°N and south to lat. 33°N. Breeding units occur throughout the species range, except in Washington. Sea lions exhibit strong site fidelity at about 50 rookeries, range-wide, and disperse after reproduction but do not migrate. Peak pupping is early June, and lactation lasts 7 months to over 1 year. Sexual maturity occurs at age 4-6 in females, while gestation lasts 9 months after a 3-month delayed implantation. The mating system is polygamous.

Northern sea lions feed on Pacific salmon, squid, Pacific herring, groundfish (such as walleye pollock), and other finfish species. Walleye pollock greater than 25cm predominate in the sea lion's diet seasonally in Alaska. Female summer feeding trips can extend out to 20nmi: in winter the females may forage out to several hundred miles.

The abundance of sea lions was first noticed to be declining in Alaska in 1976. Since the late 1960s the species has declined by about 70%. From the Gulf of Alaska to the Aleutian Islands, the sea lion population has declined from 67,617 counted in 1985 to 20,679 in 1992 -- a decrease of 69% in just 7 years. The greatest decline since the 1960s has been in the eastern Aleutian Islands (94% decline), the former center of abundance of the species. During the 1980s, all areas of the species' range declined except in Southeast Alaska, British Columbia, and Oregon.

It is unclear why the decline has occurred or whether it is related to fishery activities or from some unknown natural environmental factor. Northern sea lions are the most frequent marine mammal taken in commercial fisheries. Incidental take in trawl fisheries in 1973-88 may have played an important role in the decline in the 1970s, but not in the 1980s. Food availability is considered to be one plausible hypothesis. Other factors such as disease, predation, native subsistence and entanglement in nets and debris are not significant in the decline. Intentional shooting may have been important at various times or areas.

In 1990 the northern sea lion was listed as a threatened species under the Endangered Species

Act. Since then, Federal action has been taken to restrict certain fisheries activities near sea lion breeding sites and potential habitat important for feeding; some of this habitat extends across much of the southern Bering Sea and the Gulf of Alaska. A recovery team and plan have been established to assist the NMFS in managing the potential conflict between conserving northern sea lions and the allocation of fish in domestic fisheries.

Highest Counts of Northern Sea Lions in U.S. Waters

U.S.	1956-68	1975-77	1984-86	1989-92
Alaska	150,572	129,347	89,295	34,844
Oregon[1]	-	1,785	2,503	3,035
California [2]	3,100	2,600	2,500	2,000

[1] Washington currently is 300-600.
[2] Rounded; some extrapolations among years.

For further information

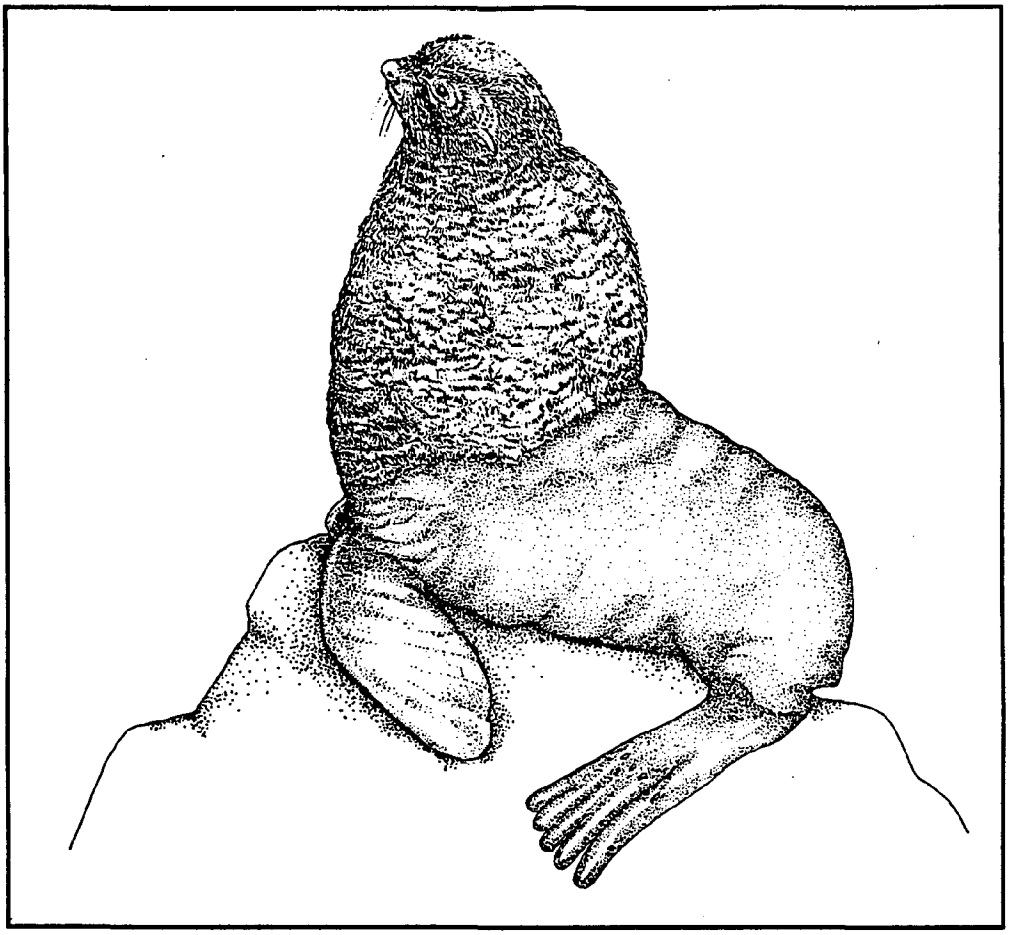
Braham, H., R. Everitt, and D. Rugh. 1980. Northern sea lion population decline in the eastern Aleutian Islands. J. Wildl. Manage. 44: 25-33.

Loughlin, T., and R. Merrick. 1989. Comparison of commercial harvest of walleye pollock and northern sea lion abundance in the Bering Sea and Gulf of Alaska. In Proceedings of the International Symposium on the Biology and Management of Walleye Pollock. p. 679-700. Alaska Sea Grant Rep. No. 89-1.

Loughlin, T.R., A.S. Perlov, and V.A. Vladimirov. 1992. Range-wide survey and estimation of total abundance of Steller sea lions in 1989. Mar. Mammmal Sci. 8:220-239.

Merrick, R., T. Loughlin, and D. Calkins. 1987. Decline in abundance of the northern sea lion in Alaska, 1956-86. Fish. Bull., U.S. 85: 351-365.

38. NORTHERN FUR SEAL

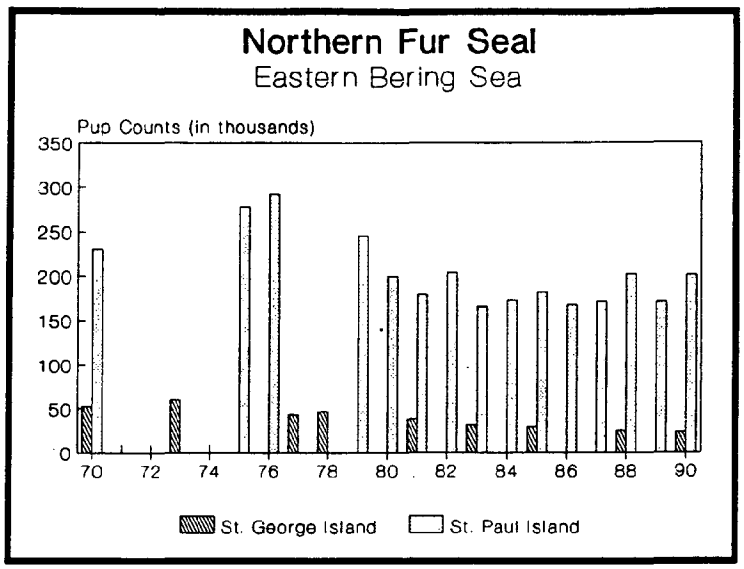


The northern fur seal (*Callorhinus ursinus*) is a monotypic species ranging across the subarctic waters of the North Pacific Ocean from the Sea of Japan, Okhotsk Sea, and Bering Sea, and southward along the coast of the temperate continental United States. Breeding populations are found on Robben Island (Okhotsk Sea); several Kuril Islands (south of Kamchatka); on the Commander, Pribilof (St. Paul and St. George Islands), and Bogoslof Islands (all in the Bering Sea); and on San Miguel Island (southern California).

Most mature fur seals are on or near their breeding islands from June to November and spend the remaining months at sea. Immature seals may or may not return to their islands of birth each year. Fur seals tend to concentrate along the continental shelf and slope where nutrient-rich waters support a variety of prey species. Some fur seals have been seen far at sea and are occasionally taken in high-seas gill-net fisheries. The southern extent of the migratory range in the eastern North Pacific Ocean is to about lat. 32°N (California-Mexico boundary) and in the western North Pacific Ocean to about lat. 36°N (off Honshu Island, Japan). The northern extent of the range is in the Bering Sea.

Older male fur seals (age 10-15 years) from the Pribilof Islands winter farther north in the North Pacific Ocean than younger males and females.

Females and young males appear during their southbound migration along the continental shelf from about lat. 57°N to 46°N in late November and off California (40°N to 38°N) in late December. In January-April, major concentrations occur between California and British Columbia. The spring (northbound) migration begins as early as March; some seals follow the continental shelf and then go westward through the Gulf of Alaska and into the Bering Sea through the eastern Aleutian Island passes. Older (10-15 year olds) males usually arrive first on the islands in May and are followed by the older females by late June. Younger males and females continue to arrive throughout summer.



The estimated total number of northern fur seals in the North Pacific Ocean in 1983 was 1.2 million. The pre-exploitation level of fur seals is unknown; the best estimate is that the Pribilof Islands population originally numbered between 2 and 3 million animals prior to the 19th century. By the early 1950s, the Pribilof herd was believed to be approaching this level, and was probably close to the carrying capacity of the ecosystem at that time. The population size on the Pribilof and Bogoslof Islands in 1988 was 982,000; this level is significantly less (about two-thirds) than observed in the 1950s when the population had reached its highest levels this century. Data collected in the 1950s, when compared to those from the 1980s through 1990, show that: 1) pup production on St. Paul Island is down by about 60%; 2) territorial males with females on St. Paul Island are down about 63%; and 3) the rookery area occupied on St. Paul Island in 1985 was less than one-third the area used in 1948. The current rate of growth of the herd is not significantly different from zero, although pup production on St. George Island continues to decline at 6% per year.

Fur seals are taken incidentally in the high-seas foreign gill-net fisheries for squid and salmon. In 1989, 208 fur seals were taken (52 dead, 128 alive, 28 lost) in 1,402 observed net retrievals (about 4-10% of the fishing operations). They are rarely taken in domestic trawl and longline fisheries. Only 1-3 fur seal were taken by trawl nets in 1990.

For further information

Fowler, C. W. 1988. A review of seal and sea lion entanglement in marine fishing debris. In D.L. Alverson and J. A. June (eds.), Proceedings of Pacific Rim Fishermen's Conference on Marine Debris, Kailua-Kona, Hawaii, 13-16 October 1987. Available Natural Resources Consultants, 4055- 21st Ave W., Seattle, WA 98199.

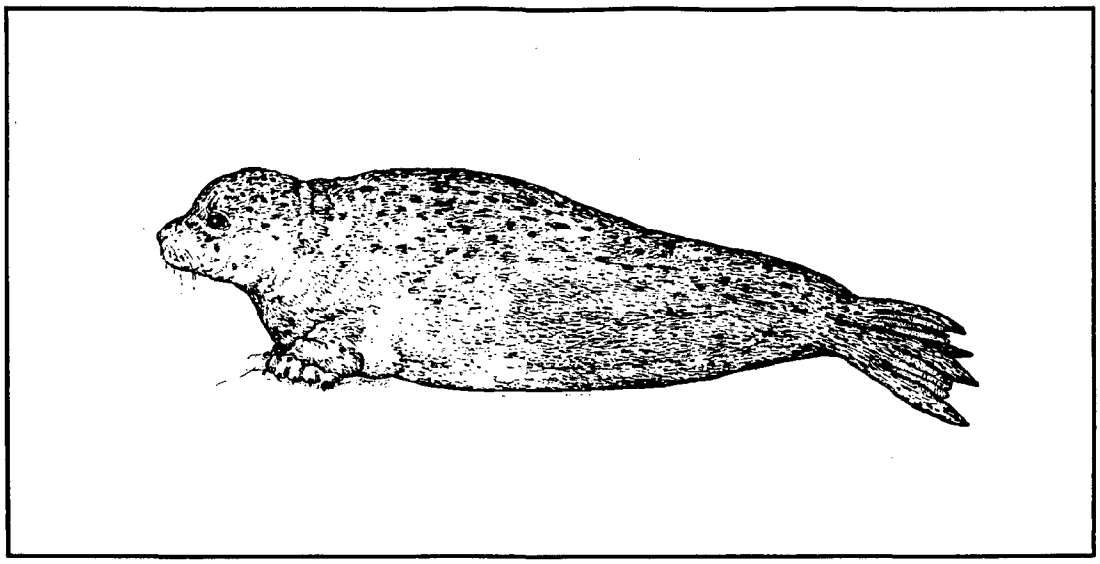
Fowler, C. W. 1990. Density dependence in northern fur seals (*Callorhinus ursinus*). Mar. Mammal Sci. 6(3): 171-195.

Loughlin, T. R., and R. V. Miller. 1989. Growth of the northern fur seal colony on Bogoslof Island, Alaska. Arctic 42(4): 368-372.

Scheffer, V. B., C. H. Fiscus, and E. I. Todd. 1984. History of scientific study and management of the Alaskan fur seal (*Callorhinus ursinus*), 1786-1964. NOAA Tech. Rep. NMFS SSRF-780, 70 p.

York, A. E., and P. Kozloff. 1987. On the estimation of numbers of northern fur seal, *Callorhinus ursinus*, pups born on St. Paul Island, 1980-1986. Fish. Bull., U.S. 85: 367-375.

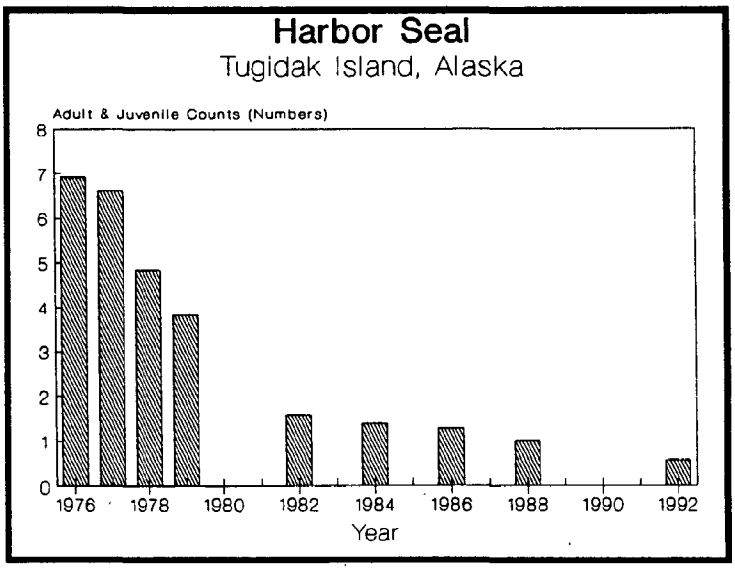
39. HARBOR SEAL



Harbor seals (*Phoca vitulina richardsi*) range from southeast Alaska to the central Bering Sea (to about lat. 59°N). They primarily occur in coastal waters where they haul-out on sand bars and rocky shores to give birth, molt, and rest. Mating generally takes place in early summer. Delayed blastocyst development of 1.5-3 months is normal, which usually takes place during the molt (late summer and autumn). Lactation lasts from 3 to 6 weeks. Age at first pregnancy is 3-6 years, but this varies throughout Alaska.

The total abundance of harbor seals in Alaska is unknown. Studies conducted in the 1970s and 1980s on Tugidak Island (southwest of Kodiak Island) indicate that the population there declined 86% over a 16-year period from 6,919 in 1976 to 571 in 1992. Similar trends may be occurring at other areas, such as along the north side of the Alaska Peninsula, but studies needed to determine the extent of the decline only began in 1991. Preliminary results of those studies indicate a continuing decline in harbor porpoise abundance in the Gulf of Alaska and stable numbers in Bristol Bay.

Harbor seals are commonly caught incidental to subsistence and commercial net fisheries; however, the nature and magnitude of the incidental take is generally unknown. Incidental take could have a significant impact considering the extent of net fishing along the coast of Alaska. The number of seals reported taken in foreign commercial trawl fisheries in the 1970s and the early 1980s was less than 10. Only two harbor seals were reported taken in domestic trawl fisheries in Alaska in 1990.



Observations of nearshore salmon fisheries in the Cooper River Delta, Prince William Sound, and Unimak Pass area only began in 1989. The extensive net fisheries in other parts of the state have not been monitored.

For further information

Everitt, R., and H. W. Braham. 1980. Aerial survey of Pacific harbor seals in the southeastern Bering sea. Northwest Sci. 54: 281-288.

Hoover, A. A. 1988. Harbor seal, *Phoca vitulina*, P. 107-157. In J.W. Lentfer (editor), Selected marine mammals of Alaska. Species accounts with research and management recommendations. Mar. Mamm. Comm., 1825 Connecticut Ave NW., Room 512, Washington, D.C 20009.

Perez, M. A., and T. R. Loughlin. 1990. Incidental catch of marine mammals by foreign and joint venture trawl vessels in the U.S. EEZ of the North Pacific, 1973-88. U.S. Dep. Commer., NOAA Tech. Rep., NMFS F/NWC-186, 81p.

Pitcher, K. W. 1990. Major decline in number of harbor seals, *Phoca vitulina richardsi*, on Tugidak Island, Gulf of Alaska. Mar. Mammal Sci. 62: 121-134.

40. SPOTTED SEAL

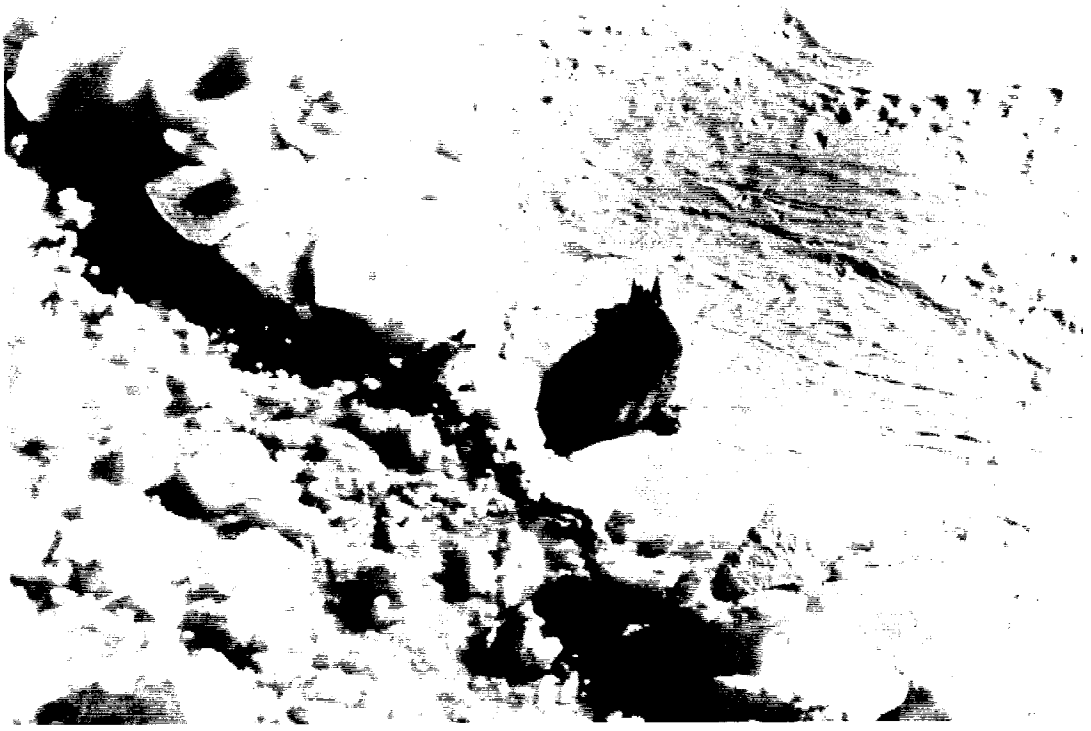


Photo: David Rugh

Spotted or larga seals (*Phoca largha*) are distributed along the continental shelf of the Beaufort, Chukchi, Bering, and Okhotsk Seas south to the northern Yellow Sea and western Sea of Japan. Eight distinct breeding areas have been identified with three in the Bering Sea: 1) Bristol Bay to the Pribilof Islands; 2) Navarin Basin to the Gulf of Anadyr (Russia); and 3) eastern Kamchatka Peninsula (Russia), from Karaginskii Bay to Olyutorski Gulf and north into the northern Bering Sea.

Spotted seals are usually associated with the southern extent of the pack ice in winter and spring, but haulout on land in the northern part of the range in summer and fall. Pupping occurs in the Bering Sea from late March through mid-May. Mating occurs at the time pups are weaned, about 4 to 6 weeks postpartum. During this period, adults are seen on ice floes as female-pup, male-female, or male-female-pup triads. Sub-adults and non-breeding animals are generally found in larger groups. In the southeastern Bering Sea, herds of spotted seals are found in close proximity to walleye pollock concentrations.

Molting occurs during late spring. Loose groups of up to 200 animals can be found associated with ice remnants, although some seals also molt on land on the eastern Bering Sea coast. This allows these seals to take advantage of spring migrations of Pacific herring. Animals move northward and inshore to the Alaskan and Siberian coasts as ice degrades and recedes. Lagoons, estuaries, mainland beaches, offshore islands, and pack-ice near land are used as haulout sites.

The current abundance of spotted seals in Alaska is unknown. In 1973 the Bering Sea population of spotted seal was estimated to have been 200-250,000 animals. This was based on opportunistic sightings and relative abundance with other species. Adult recruitment is estimated to be 9%-11%, but the growth rate of the population is unknown.

Walleye pollock, capelin, Arctic cod and herring are major prey items for spotted seals in the Bering Sea. The importance of competition between these seals and fisheries cannot be assessed at this point,

however, because data on the population dynamics and behavior of spotted seals are lacking. Based on the spotted seal's diet, utilization of the Bering Sea for feeding, foraging strategy, and population distribution, spotted seals are likely to interact directly with both the commercial groundfish and herring fisheries. U.S. fishery observers on foreign independent fishing vessels and joint venture mother ships recorded the number of marine mammals caught in ground fisheries from 1978 to the present. Between 1978 and 1986 at least 2 and perhaps as many as 22 spotted seals were observed caught, and all died. Uncertainties in this estimate are due to potential misidentification of seals. Twenty seals were caught in areas inhabited by both spotted seals and harbor seals but were all identified as harbor seals.

During the 1960s and 1970s, Russian commercial sealing and Alaskan Eskimo subsistence harvests averaged about 4-8,000 spotted seals per year in the Bering Sea, or about 3% of the juvenile and adult population. However, takes for both groups have apparently declined in recent years. Data are not available to assess the impact of intentional taking by domestic fisheries.

For further information

Braham, H. W., J. J. Burns, G. A. Fedoseev and B. D. Krogman. 1984. Habitat partitioning by ice-associated seals and walruses in the Bering Sea, April 1976, p. 25-47. In F. H. Fay and G. A.

Fedoseev (editors), Soviet-American cooperative research on marine mammals, Volume 1. Pinnipeds. U.S. Dep. Commer., NOAA Tech. Rep. 12.

Burns, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Sea. J. Mammal. 51: 445-454.

Lowry, L. F., and K. J. Frost. 1981. Feeding and trophic relationships of phocid seals and walruses in the eastern Bering Sea, p.813-824. In D.W. Hood and J. A. Calder (editors), The eastern Bering Sea shelf: Oceanography and resources., Volume 2. Juneau, Alaska, U.S. Dep. Commer., NOAA Off. Mar. Poll. Assess., U.S. Gov. Print. Off., Washington, D.C.

Quackenbush, L. T. 1988. Spotted seal, *Phoca largha*, P. 107-124. In J.W. Lentfer. (editor), Selected marine mammals of Alaska. Species accounts with research and management recommendations. Mar. Mamm. Comm., 1825 Connecticut Ave NW., Room 512, Washington, D.C 20009.

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17 SEASE, J. L., J. P. LEWIS, D. C. MCALLISTER, R. L. MERRICK, and S. M. MELLO. 1993. Aerial and ship-based surveys of Steller sea lions (Eumetopias jubatus) in Southeast Alaska, the Gulf of Alaska, and Aleutian Islands during June and July 1992, 57 p. NTIS No. PB93-226025.

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15 KINOSHITA, R. K., A. GREIG, L. E. QUEIROLO, and J. M. TERRY. 1993. Economic status of the groundfish fisheries off Alaska, 1991, 94 p. NTIS No. PB93-197861.

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12 HARRISON, R.C. 1993. Data report: 1991 bottom trawl survey of the Aleutian Islands area,144 p. NTIS No. PB93-186237.

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