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Status of Living Marine Resources off Alaska as Assessed in 1991

Alaska Fisheries Science Center
7600 Sand Point Way N.E., BIN C-15700
Seattle, WA 98115-0070

U. S. DEPARTMENT OF COMMERCE
Robert A. Mosbacher, Secretary
National Oceanic and Atmospheric Administration
John A. Knauss, Administrator
National Marine Fisheries Service
William W. Fox, Jr., Assistant Administrator for Fisheries

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CONTRIBUTORS

This report was prepared by scientists from the Alaska Fisheries Science Center, National Marine Fisheries Service. The following personnel were the major contributors for this report:

Coordinator and General Editor: Loh-Lee Low

Groundfish Resources Section: Vidar G. Wespestad, Grant G. Thompson, Anne B. Hollowed, Richard G. Bakkala, Sandra A. Lowe, Thomas K. Wilderbuer, Terrance M. Sample, Gary E. Walters, Daniel H. Ito, Harold H. Zenger, Jr., Eric S. Brown, Jeffrey T. Fujioka, David M. Clausen, Jonathan Heifetz, Pierre K. Dawson, Victoria M. O'Connell, and Patrick J. Sullivan

Pelagic Resources Section: Vidar G. Wespestad

Shellfish Resources Section: Jerry E. Reeves

Salmon Resources Section: James C. Olsen

Marine Mammal Section: Howard W. Braham

Editing, Graphics, Publication: Gary J Duker, Sharon A. Giese, Susan M. Calderon, Lowell Fritz, Julie A. Pearce, Ingrid B. Spies, Ralph S. Svrjcek, and James K. Lee

The section on Pacific halibut was written by Patrick J. Sullivan of the International Pacific Halibut Commission. The senior author for the Gulf of Alaska demersal shelf rockfish section was Victoria M. O'Connell of the Alaska Department of Fish and Game.

Artwork by D. R. Harriott in this publication was reproduced courtesy of J. L. Hart's Pacific Fisheries of Canada, Bulletin 180, Fisheries Research Board of Canada.

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INTRODUCTION

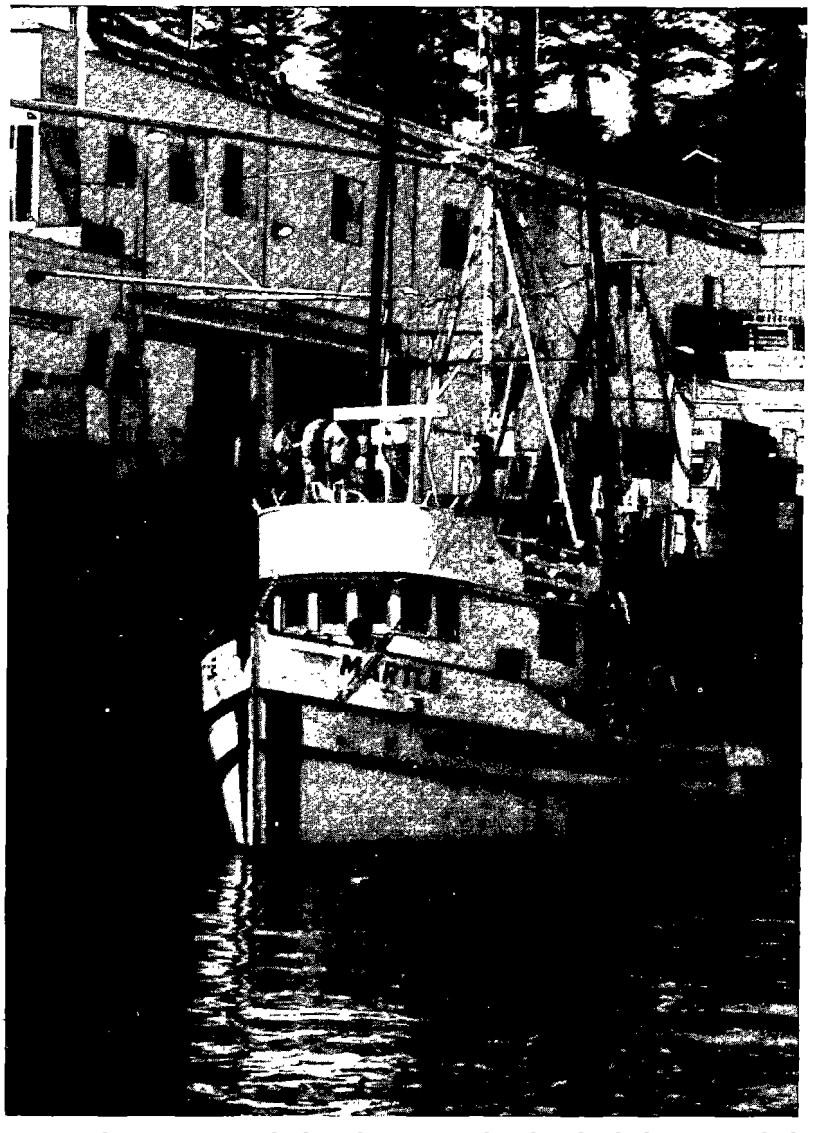
Status of Stocks Off the Coast of Alaska

This report provides a species-by-species description of the status of living marine resources off Alaska as assessed in 1991. 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. This NMFS Technical Memorandum has been compiled from reports written by scientists from the NMFS's Alaska Fisheries Science Center. It is one of five 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 regional 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 in the Federal waters and rivers of 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, Pacific halibut, and steelhead trout, and is home to an array of marine mammal species (e.g., bowhead whale, gray whale, humpback whale, killer whale, northern fur seal, and northern sea lion).

The mission of the AFSC is to plan, develop, and manage scientific research programs designed to generate the best scientific data available for the better understanding and management of 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 the Nation's living marine resources. Its primary constituents are the Pacific and North Pacific Fishery Management Councils, NMFS headquarters and regional offices, state and Federal agencies, U.S. Commissioners of international 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 Act led to one of the great success stories for development of the domestic groundfish industry off Alaska. Under the Act, joint ventures with foreign countries were first formed to involve domestic fishermen in the fisheries. By 1990, most of-the joint venture operations that replaced foreign fisheries were, in turn, replaced by purely domestic fisheries.

Under the MFCMA, the groundfish resources became subject to management by the North Pacific Fishery Management Council (NPFMC) under two fishery management plans: 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 plus the Gulf of Alaska) totals more than 3.3 million metric tons (t). The current potential yield (3.2 million t) is close to LTPY, reflecting the good condition of the stocks. For the Bering Sea/Aleutian Islands region, the average groundfish catch in recent years (1988-90) was about 1.8 million t; the ex-vessel value was about $350 million. For the Gulf of Alaska, the average 1989-90 catch was 178,000 t; the ex-vessel value was about $95 million.

For the Bering Sea/Aleutian Islands region, the dominant species groups harvested were walleye pollock (75%), flatfishes (15%), Pacific cod (7%), Atka mackerel (1.4%), rockfishes (0.4%), and sablefish (0.3%). 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 2.84 million t. The current potential yield (CPY) of 2.94 million t for 1991, as measured by acceptable biological catch (ABC), is above LTPY. Thus potential yield has not been fully utilized.

Overall abundance of groundfish in the Gulf of Alaska has been relatively stable and has risen slowly from 1984 to 1990. The most abundant species in the Gulf of Alaska is arrowtooth flounder, followed by walleye pollock and Pacific cod. The. abundances of Pacific cod, sablefish, and flatfish are high. Pollock abundance is at an average level. The abundances of slope rockfish, demersal shelf rockfish, and thornyheads are low. The abundance of pelagic shelf rockfish is unknown. The LTPY for Gulf of Alaska groundfish is 494,050 t. Currant potential yield is 740,250 t and well above LTPY because flatfishes are particularly abundant. The recent average yield (RAY) was 177,400 t, indicating that Gulf of Alaska groundfish resources are substantially underutilized.

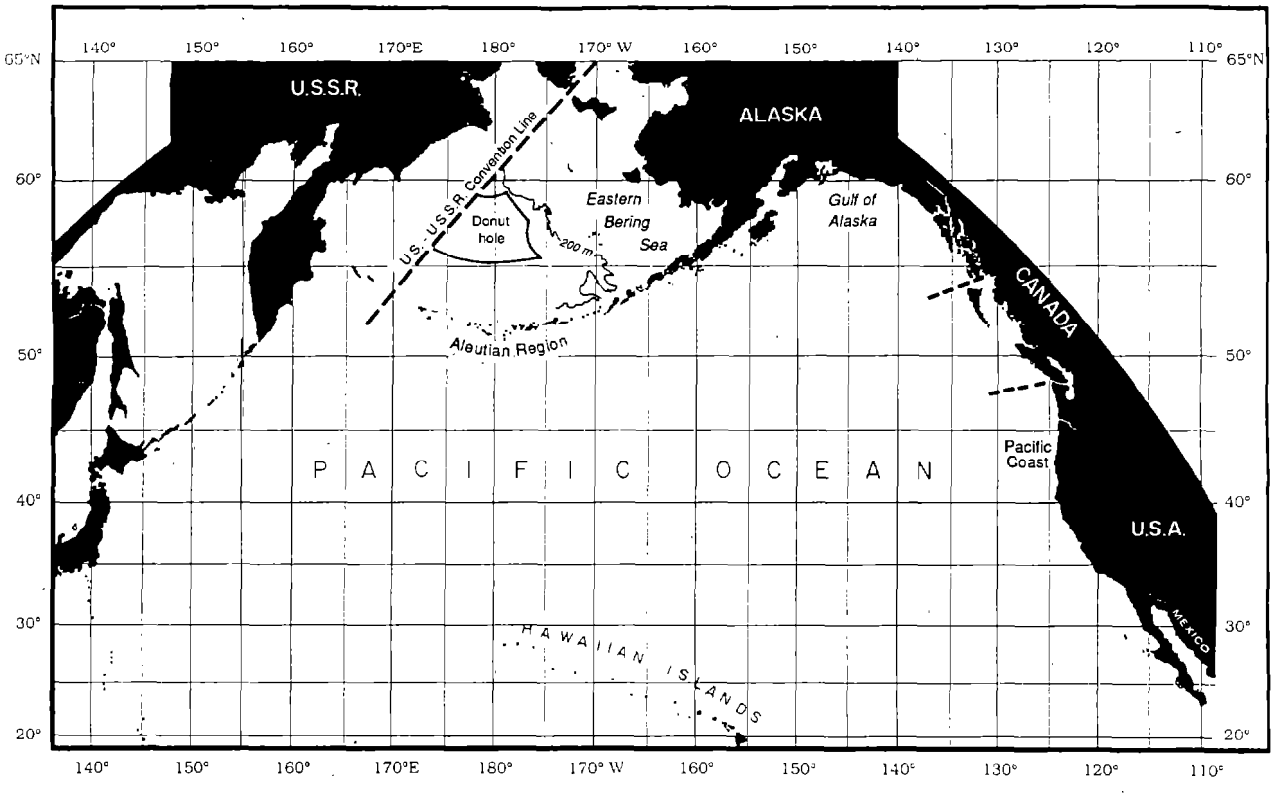
In addition to the general groundfish complexes, Pacific halibut is a groundfish species that has supported an important traditional fishery from the Bering Sea to the Pacific coast. The resource is managed by the International Pacific Halibut Commission: The LTPY of Pacific halibut totals 30,000 to 36,000 t. The CPY is 33,500 t, reflecting the good condition of the resource. Recent average catches (1988-90) were 40,800 t.

Pelagic Resources

Pacific herring is found throughout Alaska. Major concentrations in the Gulf of Alaska occur in Southeast Alaska, Prince William Sound, and Kodiak Island-Cook Inlet. In the Bering Sea, major centers of abundance

Pacific Herring Resource

	Gulf of Alaska	Bering Sea
Long-term potential yield	Unknown	Unknown
Current Potential Yield (1991)	28,200 t	16,900 t
Recent Average Yield (1977-89)	18,200 t	23,800 t
Status of Utilization	Full	Full



The range of distribution of marine resources native to Alaska.

are located in northern Bristol Bay and Norton Sound. In the Chukchi Sea and Arctic Ocean, abundance is low and commercial concentrations of Pacific herring have only been located in Kotzebue Sound. The fishery occurs in inshore areas,

In 1990, the total Pacific herring harvest was 40,700 t with an ex-vessel value of $27 million. The majority of the harvest was roe-herring (84,500 t) and the remainder was food-and-bait herring (6,200 t) and roe-on-kelp (400 t). 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, excluding Norton Sound, stocks are at very low abundance levels and are anticipated to decline further as expected recruitment continues to be weak.

Shellfish Resources

The king and Tanner crab fisheries are currently the most important shellfish fisheries in Alaska. Three species of king crab (red, blue, brown or golden) and two species of Tanner crab (Chionuecetes 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 as the abundance of the red king crab has declined. During the developmental phase of the Tanner crab fishery, C. bairdi predominated in the landings. In more recent years there has been a shift in species composition to the point where C. opilio currently dominates the catch. The Bering Sea is the only area where this species occurs in U.S. waters.

The annual ex-vessel value of Alaskan king and Tanner crab fisheries averaged $195 million during the 1978-90. period. Of that value, 61% was attributable to king crabs. The average annual value of Tanner crab landings during the 1978-90 period was $77 million. C. opilio crabs contribute to 57% of the value.

The Bering Sea/Aleutian Islands crab stocks are jointly managed by the State of Alaska and the NPFMC under an FMP. Gulf of Alaska crabs and shrimp are managed by the State of Ala&a.

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. Beginning in 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.

Bering Sea-Aleutian Islands Groundfish Resources

Species	Recent Average Yield (t) (1988-90)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Pollock	1,327,800	1,787,000	1,987,000	Full
Pacific cod	178,800	229,000	192,000	Full
Yellowfin sole	151,500	250,600	220,000	Full
Greenland turbot	8,300	7,000	27,100	Full
Arrowtooth flounder	2,200	116,400	59,000	Under
Rock sole	43,900	246,500	160,000	Under
Other flatfish	41,500	219,700	148,500	Under
Sablefish	5,200	6,300	7,500	Full
Pacific ocean perch	2,200	15,300	14,900	Full
Other rockfish	18,400	1,325	1,300	Full
Atka mackerel	12,400	24,000	25,000	Full
All Others	8,300	32,500	Unknown	Under
TOTAL	1,800,500	2,935,625	> 2,842,300	

Gulf of Alaska Groundfish Resources

Species	Recent Average Yield (t) (1988-90)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Pollock	66,800	100,000	229,000	Under
Pacific cod	50,700	77,900	39,100	Full
Sablefish	29,000	22,500	26,600	Full
Slope rockfish	16,300	17,900	21,350	Full
Flatfish	10,300	514,900	169,000	Under
Thornyhead rockfish	2,500	1,800	3,750	Unknown
Pelagic shelf rockfish	1,300	4,800	4,800	Full
Demersal shelf rockfish	500	450	450	Full
TOTAL	177,400	740,250	494,050	

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 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. Thestatus of the snail stocks is not clear, although resources are known to be generally abundant.

Salmon Resources

There are five species of Pacific salmon: sockeye, chinook, pink, chum, and coho 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 nongovernment employer in Alaska with sales exceeding those of tourism, mining, or forest products. The fishery provides recreational opportunities and is an integral part of Alaska native culture and heritage. Recent catches exceed 150 million salmon. Ex-vessel value of the 1990 catch was about $540 million.

Pacific Halibut Resource

Species	Recent Average Yield (t) (1988-90)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Bering Sea-Aleutians	3,000	2,800	---	Full
Gulf of Alaska	31,100	25,900	---	Full
Pacific Coast	300	300	---	Full
Off Canada	6,400	4,500	---	Full
TOTAL	40,800	33,500*	30,000-36000	

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

Shellfish Resources

Species	Recent Average Yield (t) (1988-90)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Tanner crabs	76,256	76,256	45,436	Full
King crabs	10,881	10,881	32,150	Full
Shrimp	340	340	22,582	Full
Sea snails	1,831	1,831	4,766	Under
TOTAL	89,308	89,308	107,934	

Pacific Salmon Resources

Species	Recent Average Yield (t) (1988-90)	Current Potential Yield (t, 1980-90)	Long-term Potential Yield (t)	Status of Utilization
Pink	118,200	110,000	110,000	Full
Sockeye	114,500	103,700	103,700	Full
Chum	36,500	38,900	38,900	Full
Coho	14,200	15,400	15,400	Full
Chinook	4,700	5,800	5,800	Full
Total	288,147	273,800	273,858	

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 governing 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 EEZ is under responsibility of the NMFS and the NPFMC off the coast of Alaska from 3 to 200 miles offshore.

Recreational fishing is permitted in all regions of the EEZ off Alaska under regulations of the Alaska Department of Fish and Game (ADF&G). The recreational catch in the EEZ is probably less than several hundred salmon with most taken in the charter boat fishery. The sport catch in 1988 was about 908,000 fish.

The five species of Pacific salmon are fully utilized. The stocks have been generally rebuilt to or are beyond previous high levels. On a regional basis, some stocks may be over-utilized. Rebuilding of some stocks, particularly chinook and coho salmon, may now be impacted by high-seas catches.

Marine Mammal Resources

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. Six species are only found in Alaska, one species, the Hawaiian monk seal, is unique to Hawaii.

Fourteen of the most commonly observed species of marine mammals are normally found close to shore, such as the California gray whale and California sea lion. 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, especially by whales and dolphins, are for traveling 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, such as humpback whales and northern fur seals, whereas others are found year-round from Alaska to California, such as harbor porpoise and Pacific harbor seals. These zoogeographic differences have led to unique 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. Both Acts require that management of marine mammals be based on the identification and enumeration of populations or stocks.

Glossary of Terms

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

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

Year **class:** Fish of the same stock born in the same year. Occasionally a stock produces a very small or large year class. The strengths of these year classes are followed closely because they can be pivotal in determining the stock abundance over **a period of years.**

Recruitment: The amount of fish, in numbers or weight, that reach a certain size or age in a specific year. This term is also used in referring to the number or weight of fish from a year class reaching a certain age. 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.

Absolute abundance: A measure of the actual size of a stock. It may be expressed in weight **(biomass)** or numbers of individual animals.

Relative abundance: An index of stock abundance, measured commonly by catch per unit effort (CPUE). The index assumes that the amount of catch per unit of fishing effort is directly proportional to abundance of the stock.

Sustainable yield: The number or weight of fish in a stock that can be *removed* from the stock without reducing the stock's biomass from one year to the next, assuming that environmental conditions remain the same.

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

Current potential yield. (CPY): 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.

Recent average yield (RAY): This is current average catch. It includes catch landings and discards.

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.

Instantaneous mortality rate: To overcome the limitation of annual rates, fisheries biologists use instantaneous rates to describe mortality. 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 be-

tween 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: $A = 1 - e^{-z}$.

Natural mortality (M) is the mortality due to natural causes. It is very difficult to estimate, and values are often assumed based on the general life history of a particular species.

Fishing mortality.(F) is the mortality due to fishing.

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

Fishing mortality rate: The part of the total mortality rate applying to a fish population that is caused by man's harvesting. Fishing mortality is usually expressed as an instantaneous rate, ranging from zero for no fishing to very high values such as 2.0. 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 life span 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..

$\mathbf{F_{max}}$ 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.

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

$\mathbf{F_{MSY}}$ is the rate of fishing mortality when maximum sustainable yield for the stock is achieved.

Exploitation rate: The proportion of a population at the beginning of a given time period that is caught during that time period (usually expressed on a yearly percentage).

Total allowable catch (TAO: It is the total regulated catch from a stock in a given time period, usually a year.

Catch quota: A portion of a TAC allocated to an operating unit, such as a size class of vessels or a country.

Virtual population analysis (or cohort analysis): This is a mathematical analysis of the abundance of a given year class (or cohort of fish) over its life in the fishery.

Yield Per Recruit Analysis: A calculation of the theoretical yield that would be obtained from a recruit if it is harvested according to a certain exploitation pattern over the life span of the fish.

1 WALLEYE POLLOCK

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 catch in 1990 was $331.6 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. Exclusive Economic Zone (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 and 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 metric tons (t) in 1972. Since 1977, catch quotas have ranged from 950,000 t 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 increasedfrom 1980 to 1984 due to increased foreign effort and have decreased in recent years as the foreign fishery was phased out

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

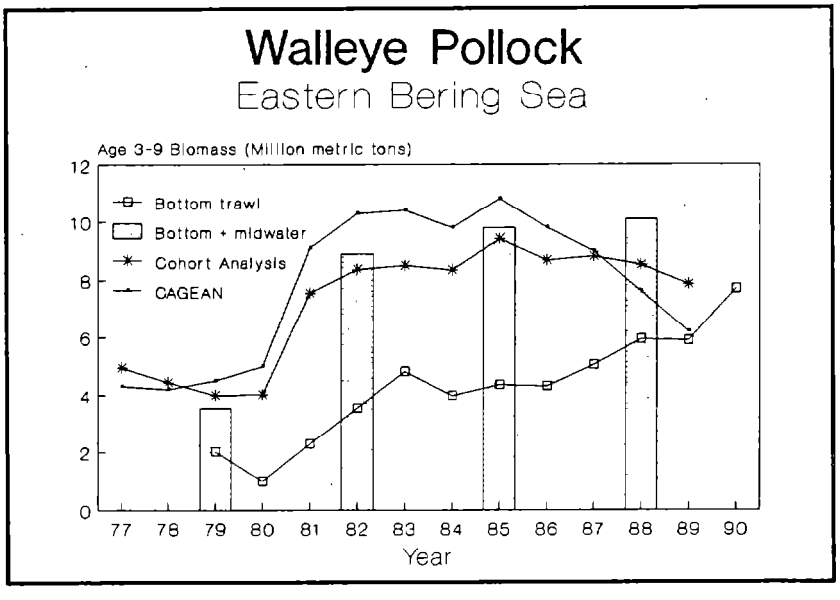
	Eastern Bering Sea			Aleutian Islands				Aleutian Basin
Year	Foreign	JVP	DAP	Foreign	JVP	DAP	Total	
1977	978	0	0	8	0	0	986	0
1978	979	0	0	6	0	0	985	0
1979	914	0	0	10	0	0	924	0
1980	948	11	0	58	0	0	1,017	15
1981	931	42	0	56	0	0	1,029	1
1982	903	53	0	56	2	0	1,014	4
1983	835	145	1	56	3	0	1,040	71
1984	862	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	1,300	0	0	17	1,340	876

JVP: Joint Venture Processing DAP: Domestic Annual Processing

and domestic fisheries began to exploit the resource.

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. In 1984, the donut hole catch was only 181,000 t. Since then, the catch has grown and in 1987 the high-seas catch exceeded the pollock catch within the U.S. Bering Sea EEZ. The second was the development of a U.S. fishery on spawning pollock in the vicinity of Bogoslof Island (Bering Sea Area 515). This fishery occur in deep water off the eastern Bering Sea shelf. In 1987 the catch was 377,000 t, but it decreased to 88,000 tin 1988 and to 36,073 t in 1989. Preliminary estimates for 1990 indicate that catch in the Bogoslof Island area increased to 149,000 t. Biological information suggests that fisheries in the central Bering Sea 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 triennially since 1979. Two age-structured population dynamics models have been employed to assess pollock: the tradi-



WALLEYE POLLOCK
Eastern Bering Sea and Aleutian Islands

	Eastern Bering Sea	Aleutian Islands
Average commercial catch (1977-89)	1.1 million t	39,071 t
Long-term potential yield (MSY)	1.9 million t	87,000 t
Acceptable biological catch (1991)	1.7 million t	85,102 t
Fishing strategy	$F_{0.1}$	$F_{0.1}$
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	Bering Sea/Aleutians Groundfish FMP	
Assessment level	Age structured	Trawl survey
Status of exploitation	Under-exploited	Unknown

M = 0.30 $F_{0.1}$ = 0.31 F_{MSY} = 0.38 $F_{(1990)}$ = 0.18

tional cohort analysis model as well as a newer catch-at-age model (CAGEAN).

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 9.4 million t in 1985. Most of the increase in the early 1980s was due to the recruitment of a very strong 1978 year class. The overall pollock population has been declining in recent years following lower levels of recruitment in the early 1980s and aging of the 1978 year class.

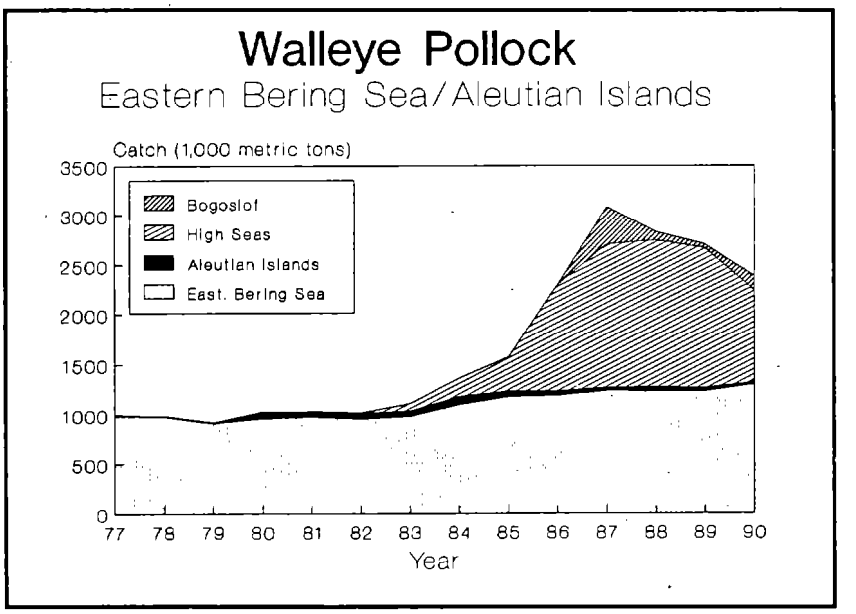
Sufficient data are not available to perform an age-structured analysis for the Aleutian Islands stock. The exploitable biomass for the Aleutian Islands region was estimated to be 527,074 t in 1986 (based on 1986 trawl survey information). Using assumptions of population trends between 1986 and 1990, the 1991 exploitable biomass is estimated to be 405,847 t.

Pollock taken in the Bogoslof Island fishery are of a noticeably different age composition than those taken on the eastern Bering Sea shelf. Estimated pollock biomass in the Bogoslof Island area (based on winter hydroacoustic surveys in 1988 and 1989) was about 2 million t. Preliminary results from a 1991 survey indicated a decline to 0.6 million t. Acceptable biological catch was 286,000 t.

This chapter was written by Vidar G. Wespestad.

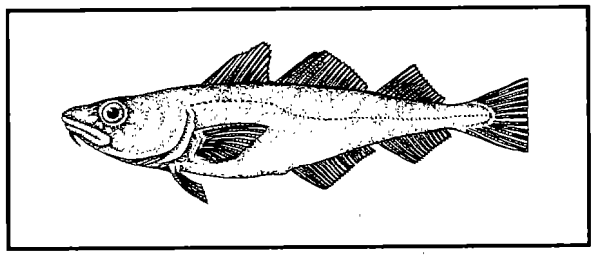
For further information

Wespestad, V. G., R. G. Bakkala, and P. Dawson. 1991. Walleye pollock. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.



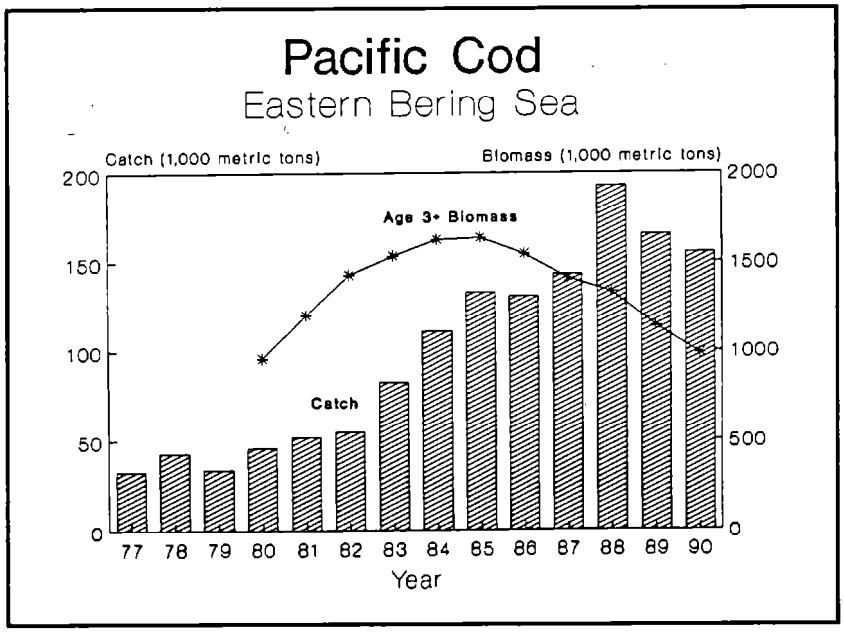
2. PACIFIC COD

In North American waters, Pacific cod (Gadus macrocephalus) occurs demersally on the continental shelf and upper continental slope from Santa Monica Bay, California, through the Gulf of Alaska, Aleutian- Islands, and eastern Bering Sea to Norton Sound. These fish 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 North Pacific Fishery Management Council's (NPFMC) Fishery Management Plans (FMP) for groundfish of the Bering Sea and Aleutian Islands region. Foreign and joint venture fleets were major participants in the fishery throughout most of the 1980s; growth in the domestic fleet has altered this fishery dramatically. The foreign fleet has not received an allocation since 1987, and the joint venture fleet received no allocation in 1991. 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 1990 were the second highest on record, with 171,000 t reported for the two areas, Without exception, the vast majority of the combined-area catches are taken in the eastern Bering Sea.

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, 1979, 1982, and 1984. helping to sustain a high biomass level. Throughout the 1980s, trawl survey estimates of biomass for the eastern Bering Sea portion of the stock have exceeded 900,000 t, peaking in 1987 at 1,142,000 t. Model estimates of biomass for this area show a peak of 1,632,000 tin 1985 (trawl survey biomass estimates are generally lower than model estimates because young fish are only partially vulnerable to the survey gear). 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 1980s. The 1990 trawl survey estimated a biomass of only 714,000 t for the eastern Bering Sea portion of the stock, with the model estimate coming in at a lo-year low of 983,000 t. Although the stock is declining, there is no evidence that it is overfished because fishing mortality rates have consistently been less than F_{MSY}.



PACIFIC COD
Eastern Bering Sea and Aleutian Islands

Average catch (1977-90)	= 108,000 t
Long-term potential yield (MSY)	= 192,000 t
Acceptable biological catch (1991)	= 229,000 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	= High and declining
Stock biomass (age 3+, model projection)	= 1,030,000 t
Harvest strategy	= F_{MSY}
Importance of recreational fishery	= Negligible
Management	= Bering Sea/Aleutians Groundfish FMP
Status of exploitation	= Fully exploited
Projected spawning stock per recruit	= Above maintenance level
Assessment Level	= Age structured

$F_{0.1}$ = 0.122 F_{MSY} = $F_{overfishing}$ = 0.156 F_{Max} = 0.232
$F_{1980\text{-}90\ average}$ = 0.088 F_{1990} = 0.104 M = 0.29

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

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Eastern Bering Sea											
Foreign	35	36	26	39	57	56	40	54	0	0	0
JV	8	7	9	10	24	36	58	47	107	44	8
Domestic	2	8	20	34	29	41	33	42	86	120	155
Subtotal	46	52	55	83	111	133	131	143	193	165	163
Aleutian Islands											
Foreign	3	3	2	2	1	1	0	0	0	0	0
JV	0	2	4	5	6	6	6	10	3	0	0
Domestic	3	6	5	3	14	6	4	3	2	4	8
Subtotal	6	10	12	10	22	13	10	13	5	4	8
Total	52	62	67	93	133	145	141	157	198	169	171

JV denotes Joint-venture

This chapter was written by Grant G. Thompson.

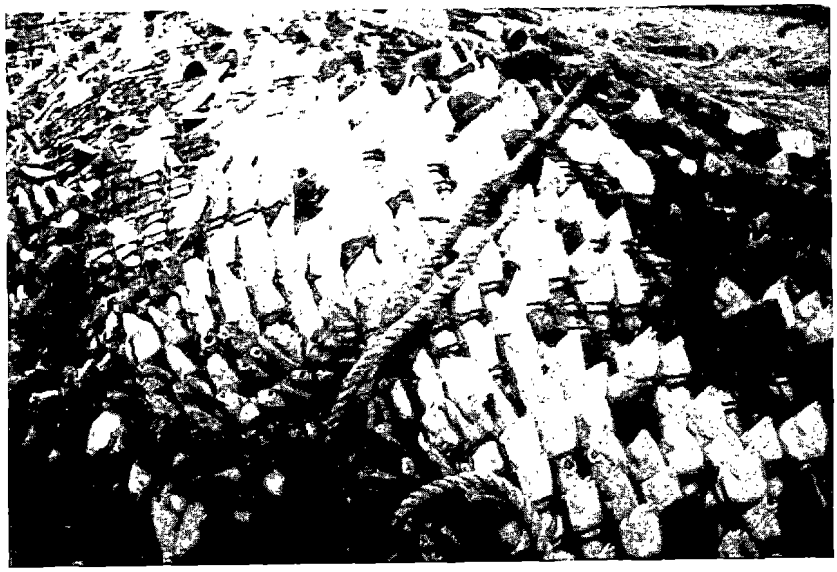
For further information

Thompson, G. G. 1990. Pacific cod. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991, p. 51-75. 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.

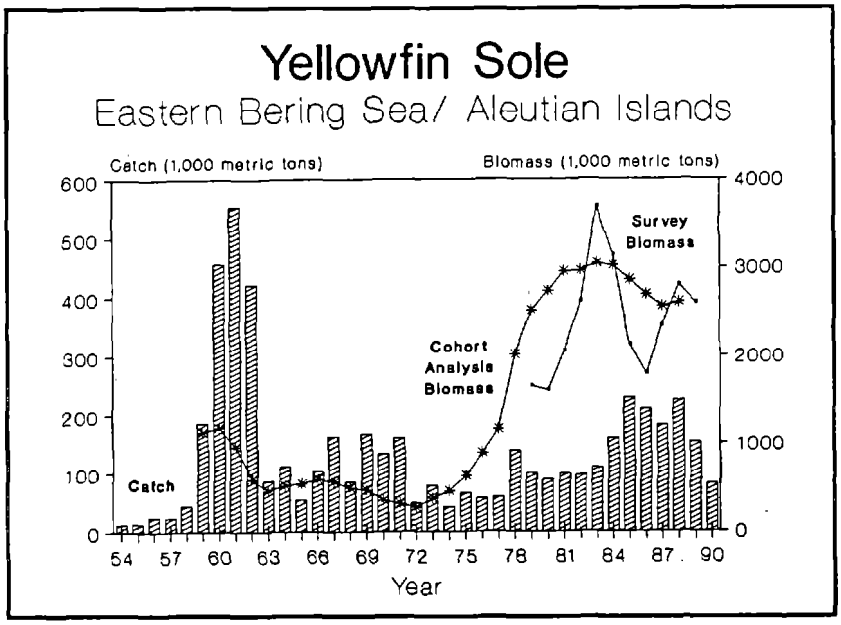
3. YELLOWFIN SOLE

Yellowfin sole (Limandu aspera) 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 move gradually 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.



Eastern Bering Sea yellowfin sole are of 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 141,353 t from 1977 to 1989. Catches declined to 80,600 t in 1990 mainly as a result of limitations on bycatch of prohibited species rather than to a decline in abundance of yellowfin sole. It has been mainly utilized for human consumption since the early 1960s.



Cohort analysis indicates 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

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

Category	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Domestic	---	---	---	---	---	---	---	9.8	1.7	10.9
Joint-venture	16.0	17.4	22.5	32.8	126.4	151.4	179.6	213.3	151.5	69.7
Foreign										
Japan	64.0	68.0	64.8	83.9	59.5	49.3	1.1	0	0	0
U.S.S.R.	---	---	---	8.0	8.2	---	---	0	0	0
ROK	17.2	10.3	21.0	34.9	33.0	7.6	0.7	0	0	0
Others	0.1	---	---	---	---	0.2	0	0	0	0
Total	97.3	95.7	108.4	159.5	227.1	208.6	181.4	223.2	153.2	80.6

ROK = Republic of Korea

YELLOWFIN SOLE
Eastern Bering Sea

Average catch (1977-89)	= 141,353 t
Long-term potential yield (MSY)	= 155,000-284,000 t
Exploitable biomass (1990)	= 1,790,000 t
Acceptable biological catch (1990)	= 250,600 t
Fishing strategy	= $F_{0.1}$
Abundance and trend	= High and declining
Status of exploitation	= Under-exploited
Importance of recreational fishery	= Nonexistent
Management	= Bering Sea/Aleutians 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 level	= Age structure model

M = 0.12 $F_{0.1}$ = 0.14 F_{Max} = 0.50 $F_{1990} < F_{Max}$
$F_{1977\text{-}89\ average}$ = 0.057 $F_{overfishing}$ = 0.17

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 1990 survey estimate was 2.2 million t. Results of cohort analysis have indicated that biomass was 3.0 million t in 1981-84 but declined to 2.6 million t in 1988.

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 classesstill support the population and there is good recruitment from some later year classes, particularly those of 1981 and 1983, which maybe two of the strongest yet observed. Abundance of eastern Bering Sea yellowfin sole is at a high level and strong incoming year classes should maintain the stock in good condition.

This chapter was written by Richard G. Bakkala and Thomas K. Wilderbuer.

For further information

Bakkala, R. G., and T. K. Wilderbuer. 1990. Yellowfin sole. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991, p. 76-93. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, AK 99510.

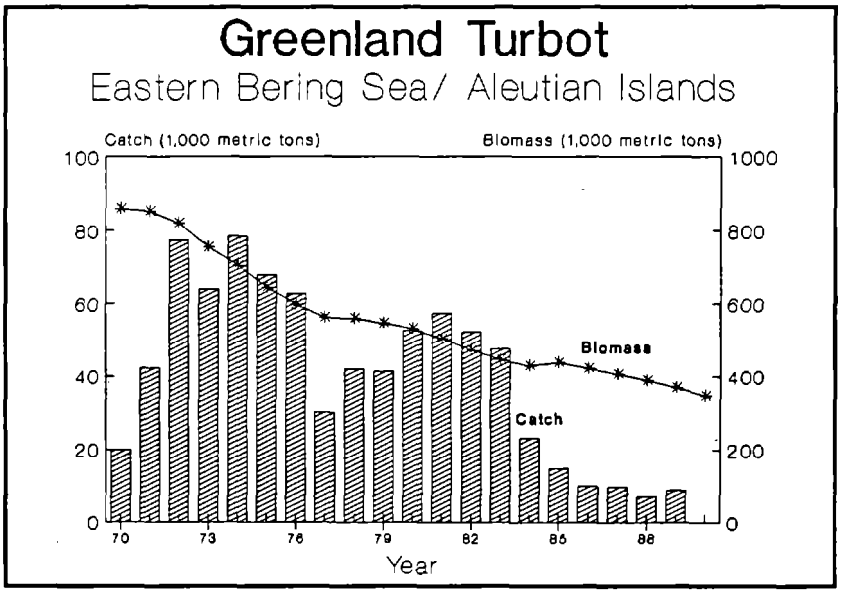
4. GREENLAND TURBOT

Greenland turbot *(Reinhardtius hippoglossoides)* is a demersal flatfish species distributed in the Atlantic and Pacific Oceans. In the North Pacific, Greenland turbot are most abundant in the eastern Bering Sea and Aleutian Islands region. 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.

Greenland turbot is a large flatfish that may live more than 20 years and reach sizes as great as 102 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 ranging from 48,060 to 57,000 t. Catches have continued to decline to less than 10,000 t since 1986. This decline is primarily due to catch restrictions placed on the fishery because of poor recruitment.

Results from surveys conducted every 3 years on the eastern Bering Sea shelf in 1975 and 1979-90 have shown a significant decline in the juvenile population. In addition, surveys of the continental slope indicated



strong recruitment of fish fish 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 US. research vesse1 and Japanese commercial vessels indicate the bottom trawl survey of the continental slope underestimate the biomass of Greenland turbot. Because of this, stock-reduction analysis has been used to estimate the biomass and trend since 1960 **and** to evaluate the consequences of various levels of fishing mortal& Results of the analysis suggest that the biomass of Greenland turbot has steadily decreased from virgin levels of over 1 million t in 196O to 347,OOO tin 1990. These values should be viewed with caution since an integral part of this analysis assumes that the shape of the spawner-recruit relationship is known. The relationship is actually poorly understood

This chapter was written by Thomas K Wilderbuer and Terrance M. Sample.

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

Year	Foreign	Joint Venture	Domestic	Total
1980	52.5	<0.1	0	52.5
1981	57.3	<0.1	0	57.3
1982	52.1	<0.1	0	52.1
1983	47.6	<0.1	0	47.6
1984	23.1	<0.1	0	23.1
1985	14.7	<0.1	0	14.7
1986	6.9	0.1	3.0	9.9
1987	1.0	<0.1	8.5	9.6
1988	0	<0.1	7.0	7.1
1989	0	<0.1	8.8	8.8
1990	0	0	6.7	6.7

GREENLAND TURBOT
Eastern Bering Sea and Aleutian Islands

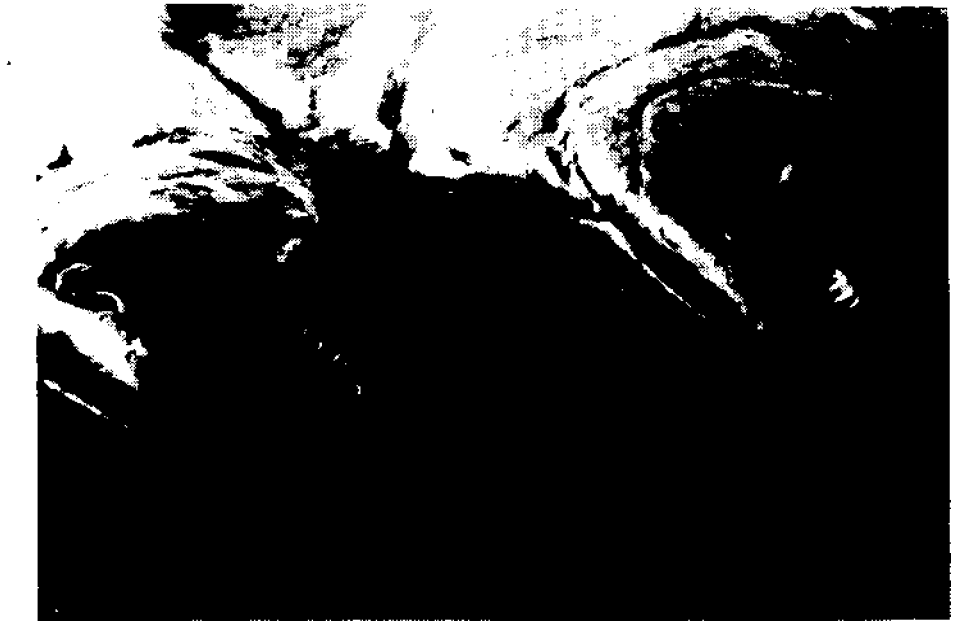
Average catch (1977-89)	= 28,300 t
Long-term potential yield (MSY)	= 27,100 t
Exploitable biomass (1990)	= 325,500 t
Acceptable biological catch (1990)	= 7,000 t
Fishing strategy	= Equal to recent catches
Abundance and trend	= Low and decreasing
Status of exploitation	= Fully exploited
Importance of recreational fishery	= Non-existent
Management	= Bering Sea/Aleutians 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 level	= Yield per recruit and stock reduction analysis

$M = 0.18$ $F_{0.1} = 0.062$ $F_{MSY} = 0.08$ $F_{1990} = 0.021$
$F_{1977\text{-}89} = 0.069$ $F_{overfishing} = 0.068$

For further information

Wilderbuer, T. K. and T. M. Sample. 1990. Greenland Turbot. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sesa/Aleutian Islands region as projected for 1991, p. 94-107. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

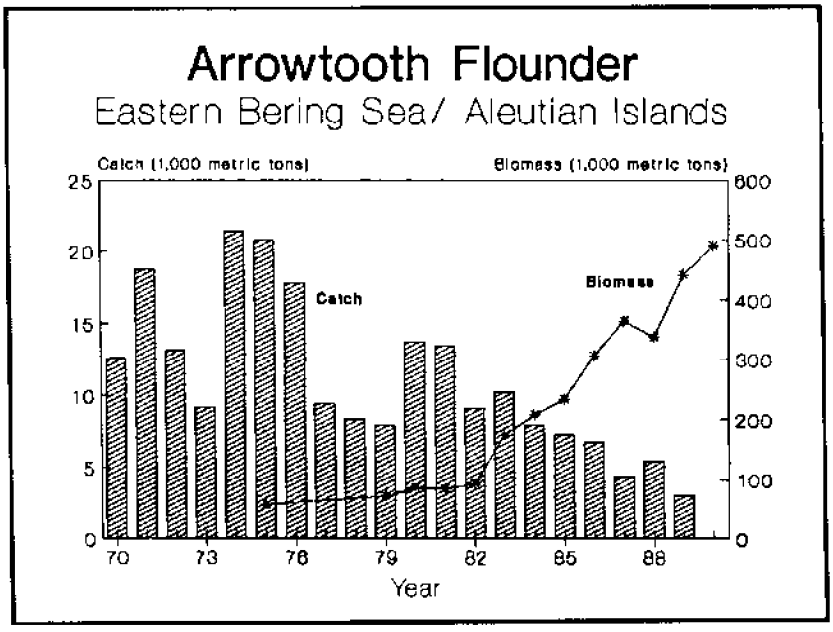
5. ARROWTOOTH FLOUNDER



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. It reaches a maximum length of 84cm and ages over 15 years. 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 have decreased annually since then to 3,000 t in 1990. 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 EEZ. Arrowtooth flounder is underutilized as a commercial species.

Biomass estimates from bottom trawl surveys on the Bering Sea shelf and slop have revealed moderate increase in arrowtooth



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

Category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Foreign	18.3	17.1	11.4	13.9	9.2	6.9	3.5	2.8	0	0
Joint Venture	<0.1	<0.1	<0.1	<0.1	0.3	0.5	3.4	1.7	2.6	2.3
Domestic	0	0	0	0	0	<0.1	<0.1	0.1	3.3	0.9
Total	18.4	17.1	11.5	14.0	9.5	7.4	6.9	4.5	5.9	3.2

ARROWTOOTH FLOUNDER
Eastern Bering Sea and Aleutian Islands

Average catch (1977-88)	= 10,925 t
Long-term potential yield (MSY)	= 59,000 t
Exploitable biomass (1990)	= 590,400 t
Acceptable biological catch (1990)	= 116,400 t
Fishing strategy	= $F_{0.1}$
Abundance and trend	= High and increasing
Status of exploitation	= Under-exploited
Importance of recreational fishery	= Non-existent
Management	= Bering Sea/Aleutians 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 level	= Yield per recruit

M = 0.20 $F_{0.1}$ = 0.18 F_{Max} = 0.41 F_{1989} = 0.005
$F_{1977-89}$ = 0.075 $F_{overfishing}$ = 0.25

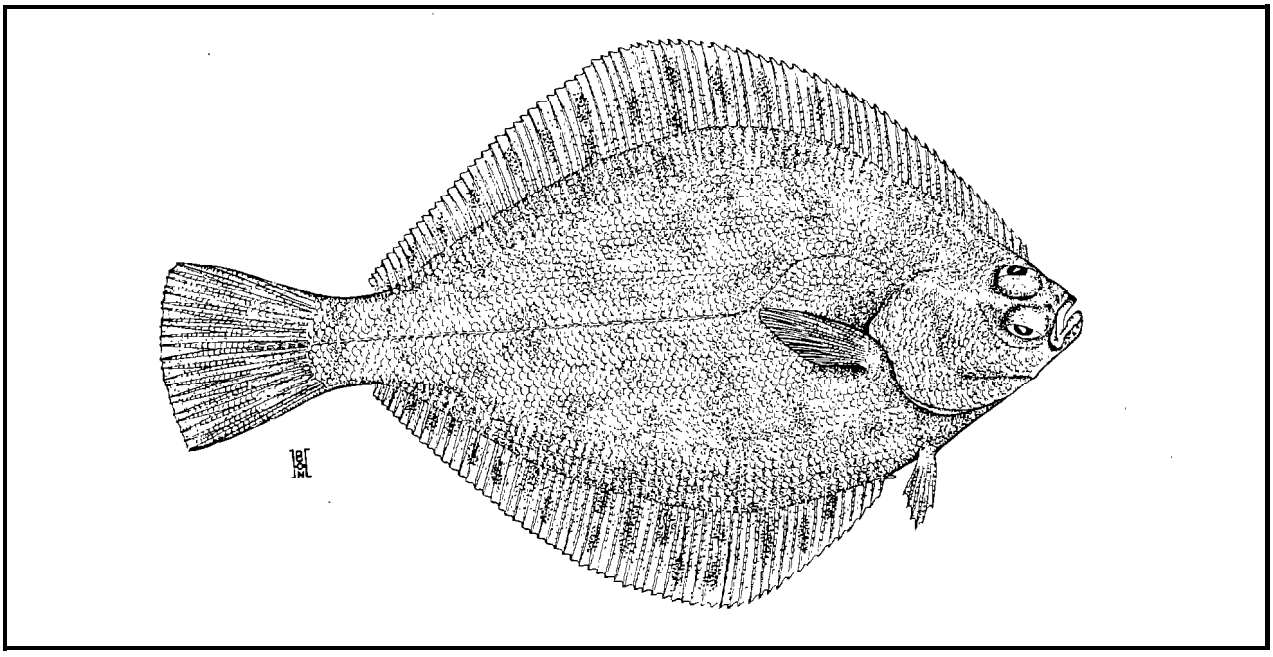
flounder abundance from 1975 (58,000 t) through 1982 (92,000 t). Significant increases in total biomass have been observed since the early 1980s reaching nearly 490,000 tin 1990. Trawl surveys conducted in the Aleutian Islands have indicated that the resource also increased there during the 1980s from 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.

This chapter was written by Terrance M. Sample and Thomas K. Wilderbuer.

For further information

Sample, T. M., and T. K. Wilderbuer. 1990. Arrow-tooth flounder. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991, p. 108-117. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

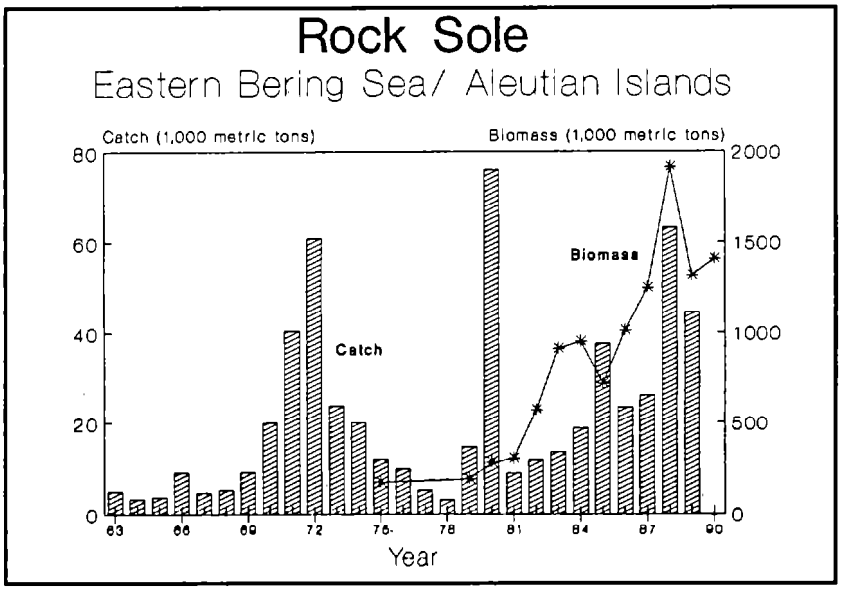
6. ROCK SOLE



Rock sole (Lepidopsetta bilineata) 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 on the eastern Bering Sea continental shelf. Spawning occur 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: bilineata bilineata (Ayers) off the west coast of North America, L. bilineata peracuata (Cope) of the Gulf of Alaska and Bering and Okhotsk Seas, and L. bilineuta mochigaeri Snyder of the northwestern Pacific Ocean. In practice, 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 de-



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

Category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Foreign	5.1	3.5	3.2	4.5	10.2	6.7	3.4	0.8	0	0	0
J.V.	2.5	5.5	8.7	9.1	27.5	12.1	16.2	11.1	40.8	21.0	10.5
Domestic	0	0	0	0	0	0	0	14.2	22.4	23.5	13.6
Total	7.6	9.0	10.9	13.6	37.7	18.8	19.6	26.1	63.2	44.5	24.1

ROCK SOLE
Eastern Bering Sea

Average Catch (1977-89)	= 20,276 t
Long-term potential yield (MSY)	= 136,400-184,000 t
Exploitable biomass (1990)	= 1,364,000 t
Acceptable biological catch (1990)	= 246,500 t
Fishing strategy	= F_{MSY}
Abundance and trend	= High and stable
Status of exploitation	= Under-exploited
Importance of recreational fishery	= Non-existent
Management	= Bering Sea/Aleutians 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 Level	= Dynamic pool models

$M = 0.2$ $F_{0.1} = 0.159$ $F_{MSY} = 0.176$ $F_{1990} = 0.018$
$F_{1977\text{-}89} = 0.0257$ $F_{overfishing} = 0.176$

clined 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 primarily due to the bycatch of valuable Pacific halibut and crab species taken in the pursuit of rock sole. Bock sole is currently underutilized with a very low fishing mortality rate.

Biomass of rock sole is estimated from bottom trawl surveys. Bock sole biomass was relatively stable from 1975 to 1979, but then increased substantially throughout the 1980s from 951,000 t in 1979 to 1.4 million t in 1990. 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 1986. Estimates of age composition in 1989 indicated that 89% of the population numbers were ages 3-8, corresponding to the 1981-86 year classes. In addition, the continuing strength of the 1975-80 year classes support the current stock biomass.

This chapter was written by Gary E. Walters and Thomas K. Wilderbuer.

For further information

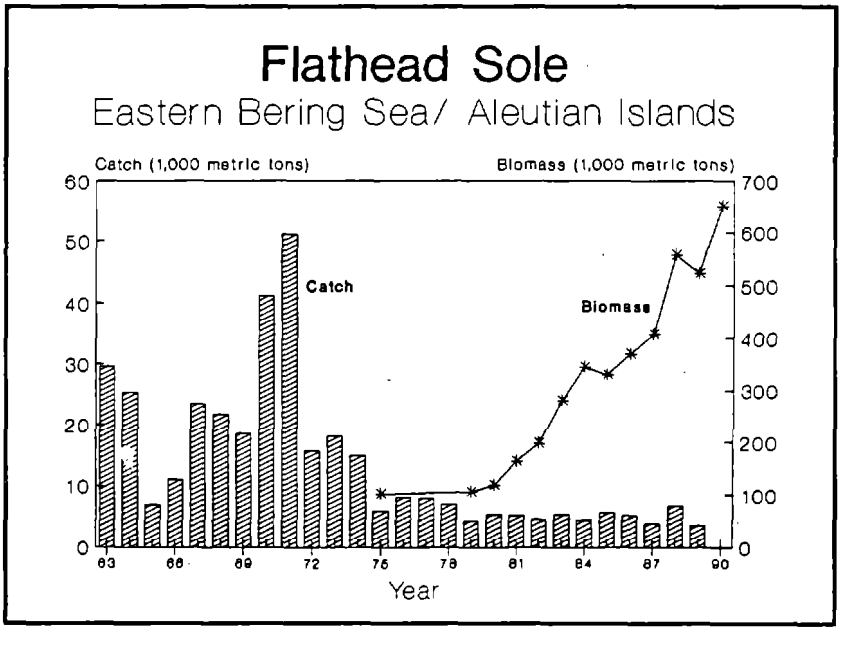
Walters, G. E., and T. K. Wilderbuer. 1990. Bocksole. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991, p. 118-128. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

7. OTHER FLATFISH

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 (Glyptocephalus zachirus), Dover sole (Mictostomias pacificus), starry flounder (Platichthys stellatus), longhead dab (Limanda proboscidea), and butter sole (Isopsetta isolepis). With the exception of Alaska plaice and flathead sole, these species are not abundant in the eastern Bering Sea.

Flathead Sole

Flathead sole range from Point Reyes, California, along the US. west coast and British Columbia into the Gulf of Alaska, Bering Sea, Aleutian Islands, and the Kuril Islands. It is by far moat 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. Females are mostly mature by age 2, but whether or not spawning occurs at this age is unknown.



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

Category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Flathead Sole										
Foreign	5.1	5.1	4.3	4.4	3.6	2.6	0.7	0.2	0	0
Joint Venture	0.1	0.1	0.2	0.8	0.9	3.1	4.5	3.7	6.8	3.5
Domestic	0	0	0	0	0	0	0	0.01	0	0.02
Total	5.2	5.2	4.5	5.2	4.5	5.7	5.2	3.9	6.8	3.5
Alaska Plaice										
Foreign	6.8	8.4	6.6	9.1	15.1	11.3	6.2	0.8	0	0
Joint Venture	0.1	0.2	0.2	1.6	3.7	13.6	40.3	17.5	61.7	13.8
Domestic	0	0	0	0	0	0	0	0.05	0	0.07
Total	6.9	8.6	6.8	10.7	18.8	24.9	46.5	18.4	61.7	13.9

OTHER FLATFISH
Eastern Bering Sea and Aleutian Islands

	Flathead Sole	**Alaska Plaice**
Average catch (1977-90)	= Unknown	Unknown
Long-term potential yield (MSY)	= 65,100 t	76,600 t
Exploitable biomass (1990)	= 587,450 t	562,400 t
Acceptable biological catch (1991)	= 106,500 t	99,000 t
Fishing strategy	= F_{MSY}	F_{MSY}
Abundance and trend	= High and increasing	High and stable
Status of exploitation	= Under	Under
Importance of recreational fishery	= Nonexistent	Nonexistent
Management	= Bering Sea/Aleutians 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 level	= Yield per recruit	
M	= 0.2	0.2
F (0.1)	= 0.159	0.159
F (MSY)	= 0.176	0.176
F (1989)	= 0.007	0.023
F (1977-89)	= 0.021	0.035
F (overfishing)	= 0.176	0.176

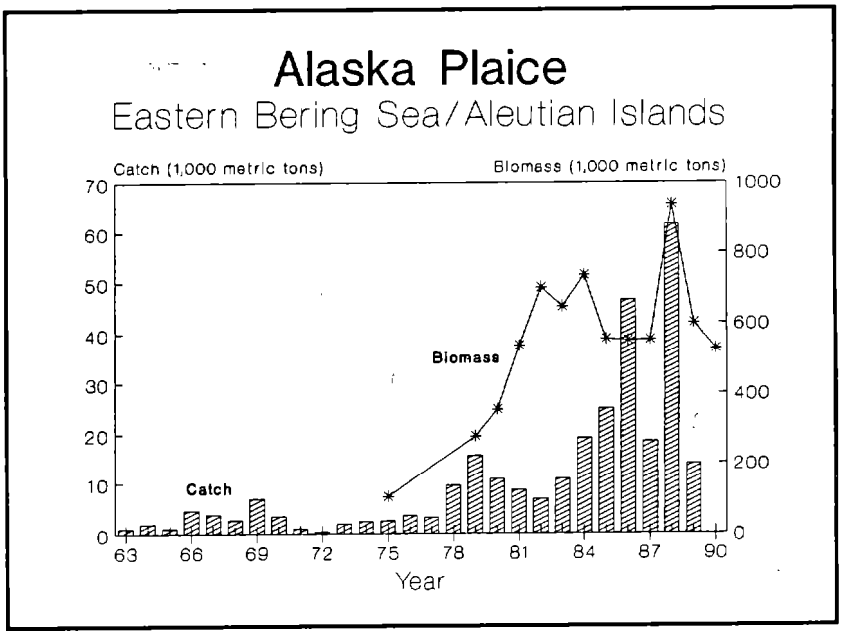
Spawning occurs during the spring.

Flathead sole is managed under the NPFMC's multispecies FMP. It is of limited commercial importance and is 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 4,946 t. Flathead sole is 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 tin 1975 to over 650,000 t in 1990. 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. Highest concentrations are found on the middle shelf area southeast of St. Matthew Island primarily at depths less than 150 m. Alaska plaice is a relatively large flatfish and may reach a length of 60 cm and an age of over 20 years. Maturity samples collected by U.S. fishery observers indicate that 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 MFCMA in 1977 have increased to a high of 61,600 t in 1988 and have averaged 18,800 t. Alaska plaice is 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.

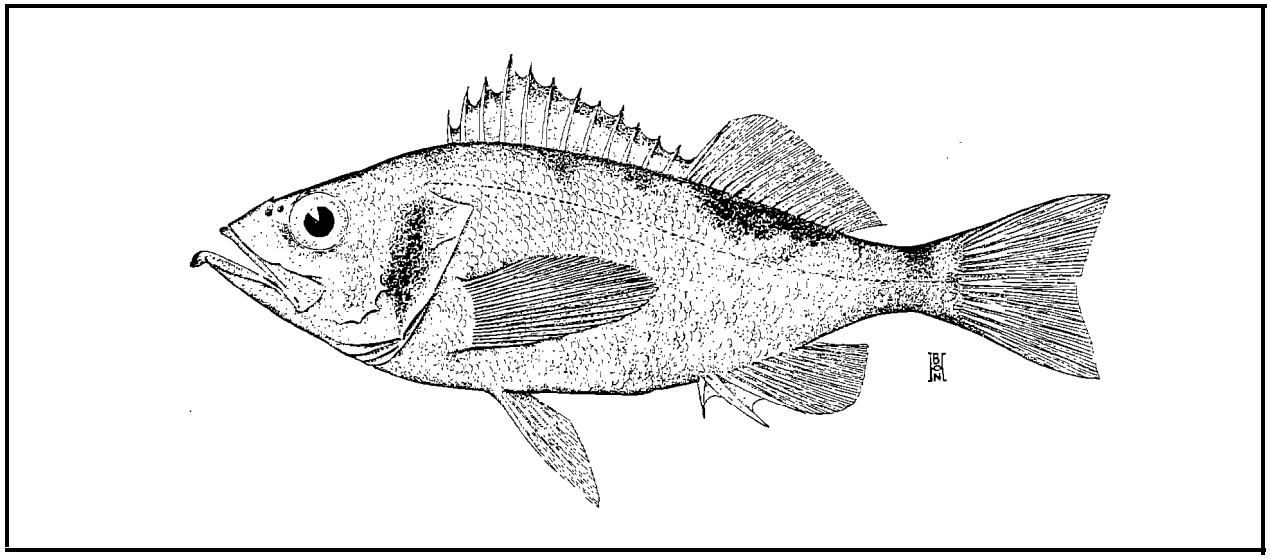
This chapter was written by Gary E. Walters and Thomas K. Wilderbuer.

For further information

Walters, G. E. and T. K. Wilderbuer. 1990. Other flatfish. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands Region as projected for 1991, p. 118-128. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

Zhang, Chang I. 1987. Biology and Population Dynamics of Alaska Plaice, Pleuronectes quadrituberculatus, in the eastern Bering Sea. Ph.D. Dissertation, Univ. Washington, Seattle, WA, 225 p.8.

8. PACIFIC OCEAN PERCH



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. From 1979 to 1990, Pacific ocean perch and 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 complex in the two distinct areas. Of the five species that comprise the Pacific ocean-perch complex, S. alutus has historically been the most abundant and has contributed the most to the commercial landings. Furthermore, the bulk of the research on rockfish has been 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. Natural mortality rate (M) equals 0.05. This species begins to recruit to the commercial fishery at about age 5 and are fully recruited by age 10, corresponding 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 regarding the four other species within the Pacific ocean perch 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 on the order of 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 cope with such large removals from their populations.

With the implementation of the MFCMA in 1977, the initial phase out of the foreign trawl fishery in waters off Alaska began. Coincident with this phase out, **a** significant domestic rockfish fishery developed. The domestic fishery first started out as a joint venture operation 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, larger sized species that inhabit deeper waters (300 m) of the continental slope.

Stock assessments based on CPUE data from Japanese commercial trawl fisheries indicate that stock abundance declined to very low levels in both the eastern Bering Sea and Aleutian Islands region. By 1977, CPUE values had dropped by more than 90-95% from those of the early 1960s, suggesting a depressed stock condition.

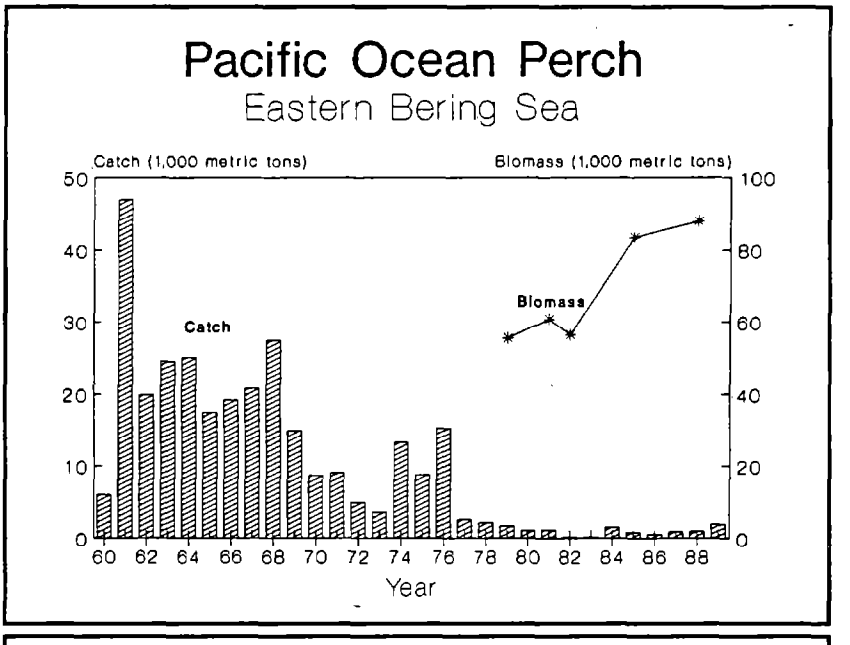
Based on results from stock-reduction analysis modeling, the best estimate of exploitable biomass for Pacific ocean perch at the beginning of 1990 amounted to 91,400 t for the eastern Bering Sea stock and 215,500 t for the Aleutian Islands stock. The stocks in both regions appear to be increasing in abundance. The most recent estimates of exploitable biomass for the other four species in the complex are 36,500 t in the eastern Bering Sea and 118,600 t in the Aleutian Islands.

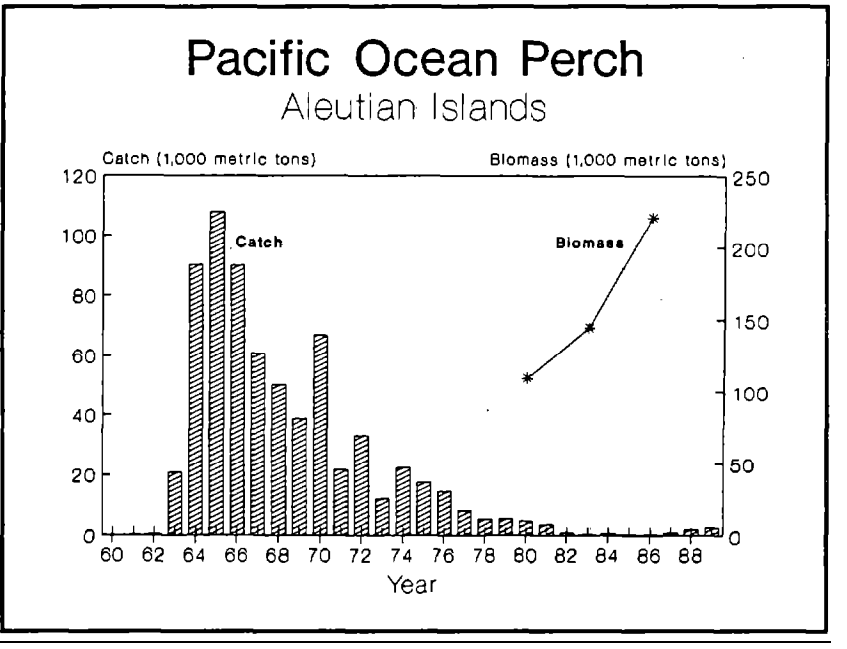
The resource is presently managed under a constant exploitation rate strategy. In the eastern Bering Sea region, the Pacific ocean perch complex is divided into two subgroups for management--a subgroup containing S. alutus only and a subgroup containing the other four species. In the Aleutian Islands region, the complex is divided into three subgroups-a subgroup containing S. alutus only, a subgroup comprised of shortraker and rougheye rockfishes; and a subgroup containing northern and sharpchin rockfishes. Separate ABCs are now calculated for each subgroup.

This chapter was written by Daniel H. Ito.

For further information

Ito, D. H. 1990. Pacific ocean perch. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991, p. 162-183. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.





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
1977	2,654	--	--	2,654	8,080	--	--	8,080
1978	2,221	--	--	2,221	5,286	--	--	5,286
1979	1,723	--	--	1,723	5,487	--	--	5,487
1980	1,050	47	--	1,097	4,700	Tr	--	4,700
1981	1,221	1	--	1,222	3,618	4	--	3,622
1982	212	3	9	224	1,012	2	--	1,014
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

JV = Joint Venture DAP = Domestic Annual Processing

PACIFIC OCEAN PERCH
Eastern Bering Sea and Aleutian Islands

Average Catch: Eastern Bering Sea (EBS)	=	1,251 t
(1977-89) Aleutian Islands (AI)	=	2,721 t
Long-term potential yield (MSY): EBS	=	4,600 t
AI	=	10,300 t
Acceptable biological catch (1990): EBS	=	4,570 t
AI	=	10,775 t
Exploitable biomass (1990): EBS	=	91,400 t
AI	=	215,500 t
Fishing strategy	=	F = M
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	=	Bering Sea/Aleutians Groundfish FMP
Status of exploitation	=	Fully exploited

M = 0.05 $F_{0.1}$ = 0.06 F_{MSY} = 0.06
$F_{overfishing}$ = unknown $F_{1977\text{-}89\ average}$ = unknown

9. OTHER ROCKFISH

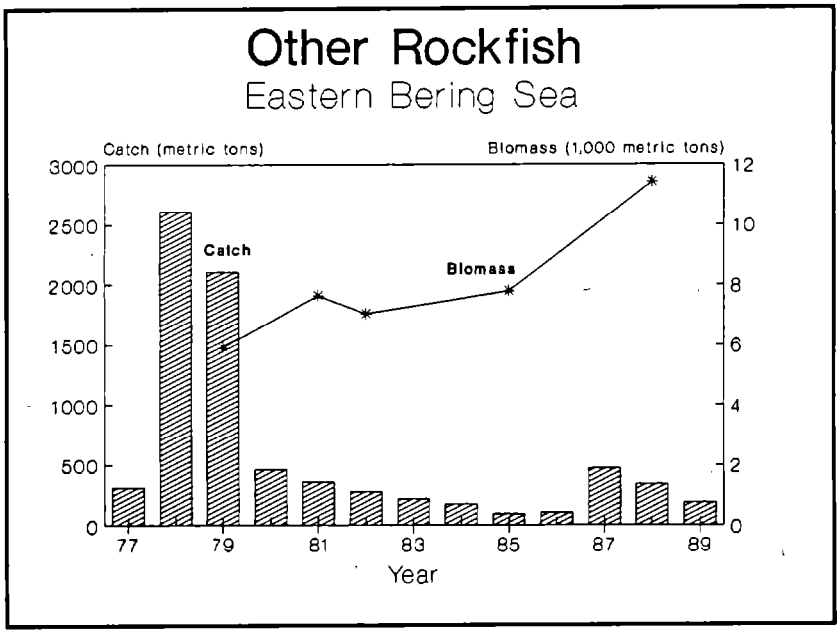
The category "other rockfish" includes Sebastolobus spp. and all species of Sebastes other than the Pacific ocean perch complex. For management purposes, the other rockfish resource is assumed to consist of two separate groups and are therefore assessed and managed as the eastern Bering Sea group and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

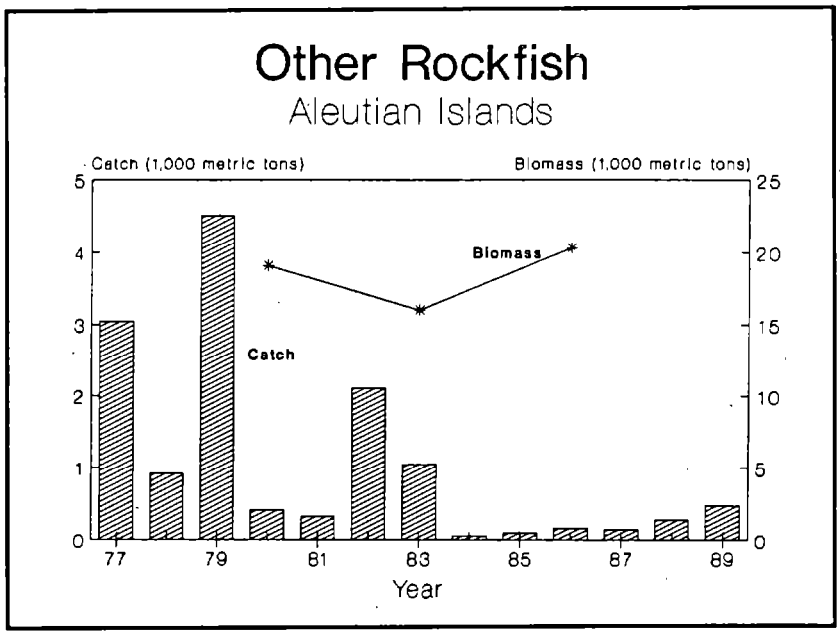
Since implementation of the MFCMA, the peak catch (2,600 t) of other rockfish in the eastern Bering Sea occurred in 1978. In the Aleutian Islands region, the peak removal occurred 1 year later in 1979 with a harvest of about 4,500 t. Catches in more recent years have been minor and are mainly incidental to other directed fisheries. The average catch during the period 1977-89 amounted to about 600 t from the eastern Bering Sea region and 1,050 t from the Aleutian Islands region.

Cooperative U.S.-Japan trawl surveys conducted from 1979 to 1988 provide absolute biomass estimates for other rockfish in the eastern Bering Sea and Aleutian Islands region. The estimates, however, are characterized by very wide confidence intervals The best estimate of current exploitable biomass for other rockfish based upon survey information is about 8,000 t for the eastern Bering Sea group and 18,500 t for the Aleutian Islands group.

Information is not available to provide a direct estimate of MSY. However, if one assumes that the exploitation and productivity patterns of other rockfish are similar to those of S. alutus, MSY is estimated at about 400 t and 900 t for the eastern Bering Sea and Aleutian Islands region, respectively.

It is assumed that the same exploitation rate used to estimate ABC for the Pacific ocean perch complex is directly applicable for estimating ABC for other rockfish. Multiplying M = 0.05 by the current exploitable -biomass, yields ABC values of 400 t for the eastern Bering Sea group and 925 t for the Aleutian Islands group.





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

Average catch: Eastern Bering Sea (EBS)	=	594 t
(1977-89) Aleutian Islands (AI)	=	1,048 t
Long-term potential yield (MSY): EBS	=	400 t
AI	=	900 t
Acceptable biological catch (1990): EBS	=	400 t
AI	=	925 t
Exploitable biomass (1990): 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	=	Bering Sea/Aleutians Groundfish FMP
Status of exploitation	=	Unknown

M = Unknown $F_{0.1}$ = Unknown F_{MSY} = Unknown
$F_{overfishing}$ = Unknown $F_{1977\text{-}89\ average}$ = Unknown

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
1977	311	--	--	311	3,043	--	--	3,043
1978	2,614	--	--	2,614	921	--	--	921
1979	2,108	--	--	2,108	4,517	--	--	4,517
1980	456	3	--	459	420	--	--	420
1981	331	--	25	356	328	--	--	328
1982	262	11	3	276	2,114	--	--	2,114
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

JVP = Joint venture DAP = Domestic annual processing

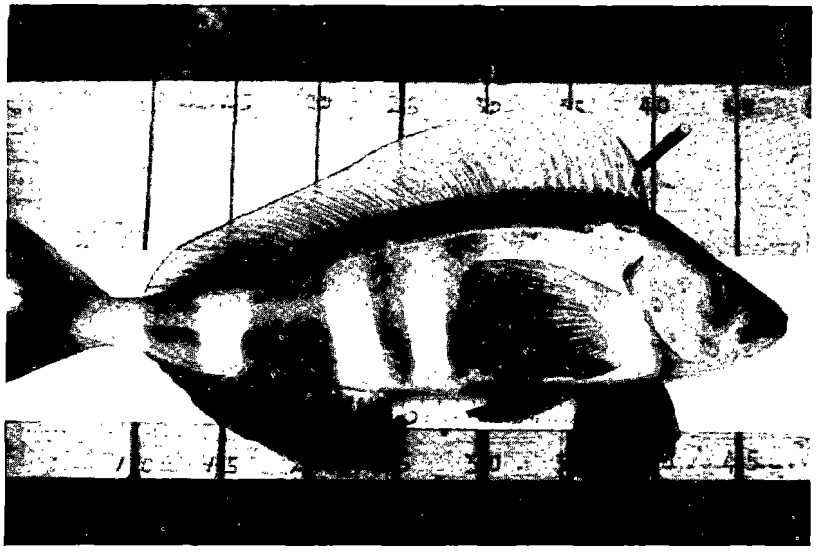
This chapter was written by Daniel H. Ito.

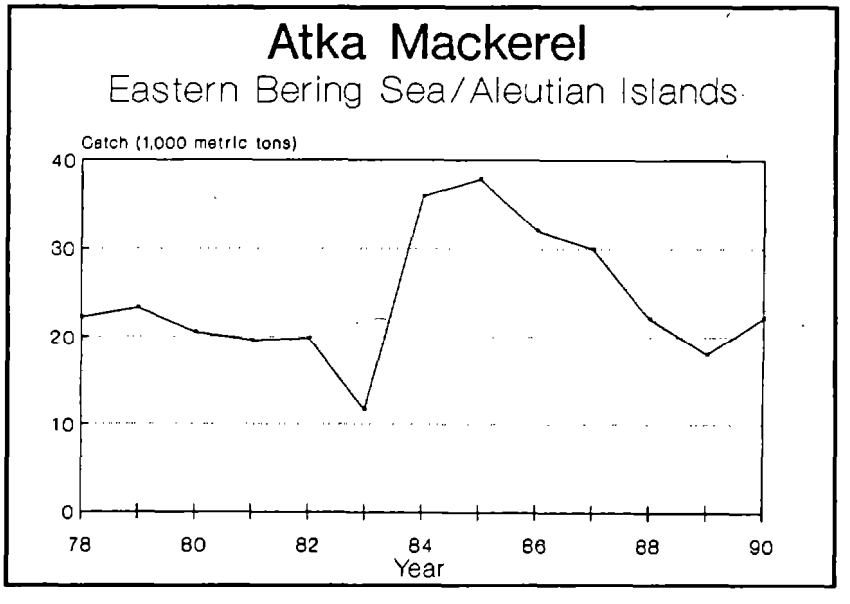
For further information

Ito, D.H. 1990. Other rockfish. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991, p. 184-187. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

10. ATKA MACKEREL

Atka mackerel (Pleurogrammus monopterygius) is a semidemersal species that frequently forms large, dense schools. It is distributed from the east coast of the Kamchatka Peninsula, throughout the Komandorskiy and Aleutian Islands, north to the Pribilof Islands in the eastern Bering Sea, and eastward through the Gulf of Alaska to Southeast Alaska. It has been reported to range to southern California, but are rare south of Alaska. The center of abundance of Atka mackerel is in the Aleutian Islands. Atka mackerel ranges from the lower intertidal area to depths of 575 m, but over 95% of its occurrences in NMFS resource assessment surveys 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 attains sizes up to 45 cm and 1.1 kg in weight. Its maximum age noted in the commercial catch is 12 years, although the bulk of the catch has consisted of young fish 3-5 years old. Spawning generally occurs during June-September at depths of 5-30 m. Atka mackerel spawns twice annually, with 5-7 days between batches of eggs during each spawning period. It is carnivorous, feeding primarily on euphausiids and pelagic fish.





Atka mackerel of the Gulf of Alaska and the Aleutian Islands are thought to belong to separate stocks baaed on morphological and meristic studies. Commercial fisheries for Atka mackerel in the Bering Sea/Aleutian Islands region are managed by the NPFMC's Bering Sea-Aleutian Islands groundfish FMP. In the Gulf of Alaska, Atka mackerel is not managed separately, but is included within the "other species" category under the Gulf of Alaska groundfish FMP. This species is not an important recreational species.

Historically, Atka mackerel has been pursued by foreign and U.S. joint venture fisheries. Until 1979, they were almost exclusively fished by the U.S.S.R.- US. joint venture fisheries which began in 1980 dominated. the catches from 1982 to 1988. In 1989 there was no joint venture allocation of Atka mackerel, and this species is now an exclusively domestic fishery. From 1979 to 1982 catches gradually declined

(23,300 t to 19,900 t) then dropped sharply to 11,706 t in 1983. The decline from 1980 to 1983 was due to changes in the target species and allocations to the nations fishing rather than changes in stock abundance. From 1984 to 1987, catches have been 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 in the Aleutian Islands has generally been from April to August. In 1990, Atka mackerel commercial landings totaled 22,205 t and had an es-vessel value of $5.2 million.

Atka mackerel occur in large, localized concentrations making them an especially difficult species to assess. Their schooling behavior makes the species difficult to survey with trawls, and because they are poor acoustic targets, they are also difficult to survey with hydroacoustic gear. Atka mackerel biomass estimates provided by NMFS bottom trawl surveys of the Bering Sea/Aleutian Islands region are quite variable for these reasons. Therefore, the current status of the stock is unknown and there is no reliable estimate of current biomass. Catch-at-age data are available for Atka mackerel, but biomass estimates are needed in conjunction with these data to assess the stock. The 1991 ABC was based on the average catch since the implementation of the MFCMA **(24,000 t).**

This chapter was written by Sandra A. Lowe.

For further information

Lowe, S. A. 1990. Atka mackerel. In Stock assessment and fishery evaluation document for groundfish resources in the Bering Sea/Aleutian Islands region as projected for 1991, p. 188-204. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

ATKA MACKEREL
Eastern Bering Sea and Aleutian Islands

Average catch (1978-90)	= 24,000 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1990)	= 24,000 t
Age/length at recruitment	= 3 years/30 cm
Maximum observed age	= 14 years
Abundance and trend	= Unknown
Exploitable biomass	= Unknown
Harvest strategy	= Average catch since FCMA
Importance of recreational fishery	= Minor
Management	= Bering Sea/Aleutians Groundfish FMP
Assessment level	= Age structured
Status of exploitation	= Unknown

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

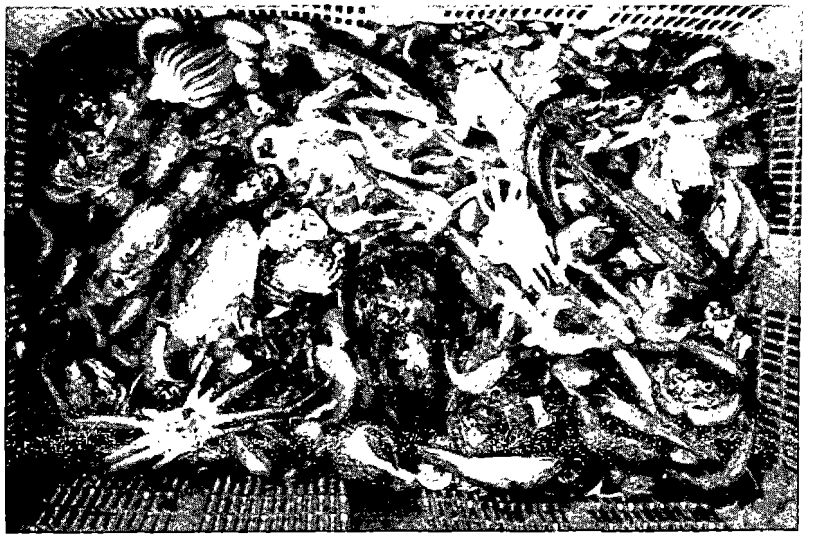
$F_{overfishing}$ = Unknown $F_{1977\text{-}90\ ave}$ = Unknown

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

Category	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Eastern Bering Sea										
Foreign	3.0	0.3	0.1	0.0	0.0	0.0	0.0	---	---	---
Joint venture	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	---
Domestic	---	---	---	---	---	---	---	0.4	3.1	0.5
Subtotal	3.0	0.3	0.1	0.0	0.0	0.0	0.0	0.4	3.1	0.5
Aleutian Islands										
Foreign	15.0	7.1	1.1	0.1	---	---	---	---	---	---
Joint venture	1.6	12.4	10.5	35.9	37.9	32.0	30.0	19.6	---	---
Domestic	---	---	---	---	---	---	---	2.1	14.9	21.7
Subtotal	16.6	19.5	11.6	36.0	37.9	32.0	30.0	21.7	14.9	21.7
Total	19.6	19.8	11.7	36.0	37.9	32.0	30.0	22.1	18.0	22.2

11. SQUID AND OTHER SPECIES

Squid



Two species of squid have been the target of commercial fisheries in the Bering Sea. The red squid (Berryteuthis magister) has dominated catches in the eastern Bering Sea, while the boreal clubhook squid (Onychoteuthis borealijaponicus) is caught largely in the Aleutian Islands region.

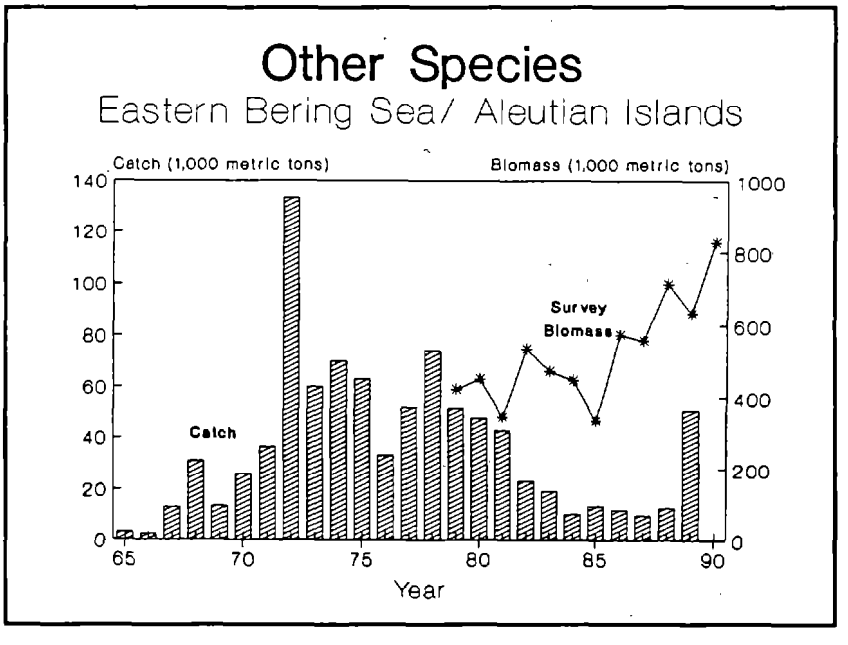
Both species are distributed across the North Pacific Ocean from the Asian to North American coasts. The red squid has the more northerly distribution being found throughout the Bering Sea north to the Bering Strait. The northward distribution of the boreal clubhook squid is limited to the southern Bering Sea. Both species inhabit pelagic waters.

The life span of the two species is 1 year. The red squid reaches a maximum mantle length of 37 cm in females and 30 cm in males.

Squid have been the target of foreign fisheries at times in the past. During the period of targeting, catches reached a maximum of about 9,000 t (in 1978). Following 1985, as foreign fisheries were phased out of the EEZ and replaced by U.S. fisheries, catches of squids have dropped to a few hundred tons annually suggesting little if any targeting on these species.

Assessment data for squid from bottom trawl surveys and other sources are not available because of their mainly pelagic distribution over deep water. The squid resource is believed to be large and only lightly exploited.

Maximum sustainable yield for squid is unknown but is believed to be at least equal to the highest catch of record. A minimum estimate of MSY has therefore been established at 10,000 t. The ABC is considered equivalent to MSY.



Other Species

The "other species" category was established by the NPFMC to account for species that are currently of slight economic value and not generally targeted upon but have potential economic value or are important components of the ecosystem. The taxonomic

groups making up this category are sculpins (Cottidae), skates (Rajidae), smelts (Osmeridae), sharks (Squalidae), and octopus (Octopodidae). A large number of species having a wide variety of distributional and life history characteristics make up this category. Little information is available on individual species. There have been 38 species of sculpins identified in the eastern Bering Sea and the Aleutian Islands management 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.

Reported catches of other species increased during the 1960s and early 1970s reaching a peak of 133,000 t in 1972. This was also the year total catches of all groundfish reached a maximum of 2.3 million t. In 1973-79, catches declined to a range of 33,000-74,000 t as total catches of groundfish also declined. Reported catches of these species declined further to a range of 5,000-14,000 t in 1984-89 despite increased catches of total groundfish and increases in abundance of other species.

Assessments of other species are based on survey data. These data show that the main components of the other species category taken by bottom trawls are sculpins and skates. These two species groups comprise between 95 and 99% of the overall estimated biomass of other species since 1981. Some of the species, however, are believed to be poorly sampled by bottom trawls, particularly the smelts, which are distributed inshore and in the pelagic region.

Survey biomass estimates indicate that sculpins were the largest single component of the other species category until 1986, when skate biomass increased and began to exceed that of sculpins. This increase in skate abundance resulted in higher biomass estimates for the overall other species category. Biomass estimates from the eastern Bering Sea have shown annual variability, but point estimates have increased from a range of 345,000-460,000 tin 1979-81 to a range of 632,000-827,000 t in 1988-90. The condition of the resource appears to be good and exploitation is well below the estimate of ABC.

This chapter was written by Richard G. Bakkala.

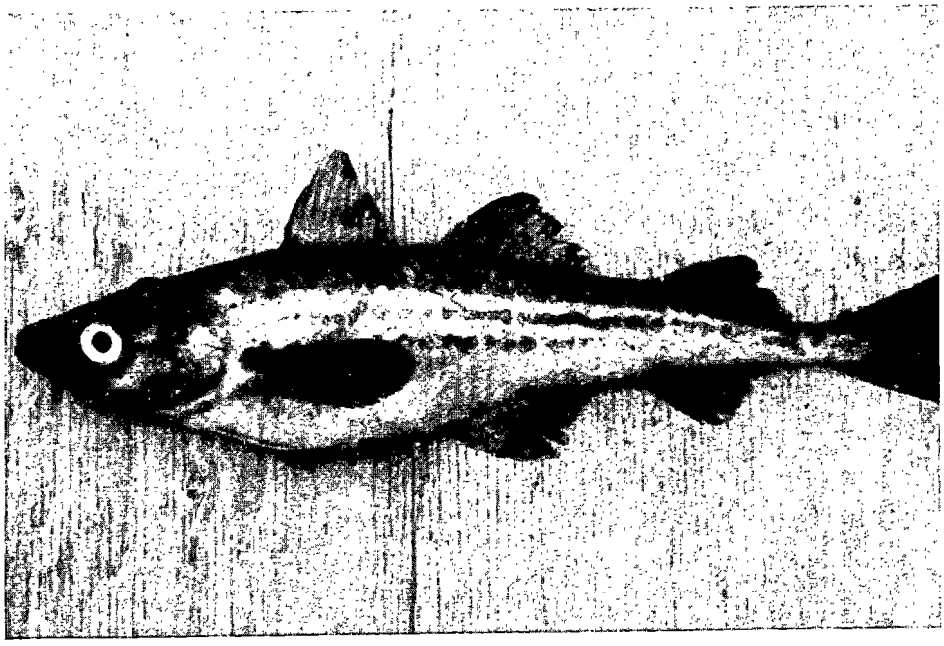
OTHER SPECIES
Eastern Bering Sea and Aleutian Islands

Average catch (1980-89)	=	19,620 t
Long-term potential yield (MSY)	=	62,900 t
Exploitable biomass	=	786,200 t
Acceptable biological catch (1990)	=	62,900 t
Fishing strategy	=	F_{MSY}
Abundance and trend	=	High and increasing
Status of exploitation	=	Under-exploited
Importance of recreational fishery	=	Nonexistent
Management	=	Bering Sea/Aleutians Groundfish FMP
Assessment level	=	Survey biomass

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

Year	Foreign	Joint venture	Domestic	Total
SQUID (in t)				
1980	6,372	--	--	6,372
1981	5,941	4	--	5,945
1982	5,034	5	--	5,039
1983	3,970	10	--	3,980
1984	3,133	34	--	3,167
1985	1,588	32	--	1,620
1986	830	38	--	868
1987	96	35	1	132
1988	--	171	246	417
1989	--	107	199	306
OTHER SPECIES (in 1,000 t)				
1980	47.0	0.7	--	47.7
1981	39.4	3.4	0.1	42.9
1982	22.3	1.1	--	23.4
1983	14.3	1.6	3.3	19.2
1984	7.5	2.6	--	10.1
1985	6.3	6.3	0.9	13.5
1986	4.0	7.6	0.4	12.0
1987	2.7	6.1	0.9	9.7
1988	--	11.8	0.8	12.6
1989	--	4.7	0.4	5.1

12. WALLEYE POLLOCK

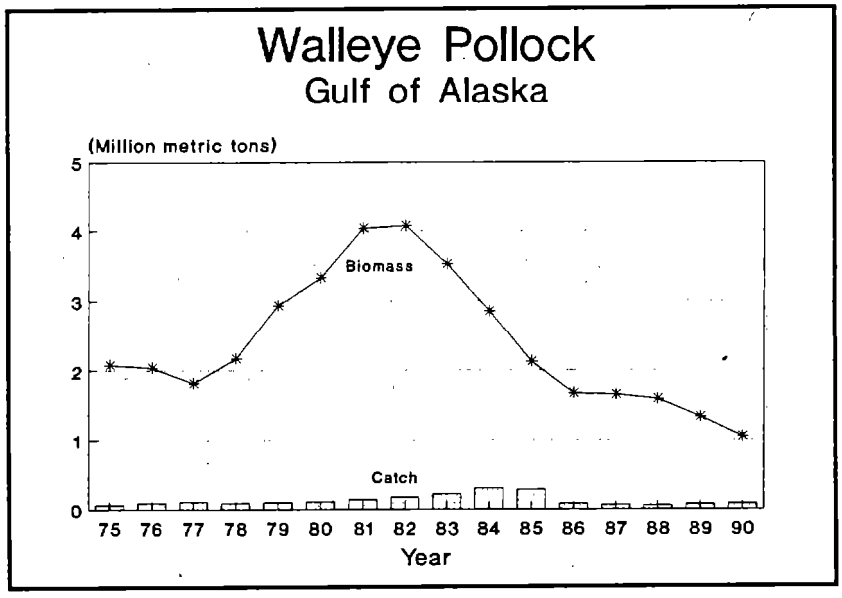


Walleye pollock (Theragra chalogramma) is a semi-demersal schooling fish that is widely distributed throughout North Pacific temperate and subarctic waters. Pollock consume a wide variety of prey in the Gulf of Alaska. In 1990, euphausiids, shrimp, and capelin (Mallotus villosus) were the principal prey 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 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.

Triennial bottom trawl surveys of the Gulf of Alaska and annual hydroacoustic surveys of Shelikof



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

Year	Foreign	JVP	DAP	Total
1977	117.8	--	0.2	118.0
1978	96.4	--	1.0	97.4
1979	103.2	0.6	2.0	105.8
1980	113.0	1.1	0.9	115.0
1981	130.3	16.9	0.6	147.8
1982	92.6	73.9	2.2	168.7
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

Strait during the spawning period (March) are conducted by the Alaska Fisheries Science Center (AFSC). Biomass estimates based on bottom trawl surveys show a stable biomass trend, whereas hydroacoustic surveys show a sharp decline. The preliminary biomass estimate from the bottom trawl survey in the summer of 1990 was 799,154 t. 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.

The entire pollock TAC in the Gulf of Alaska has been allocated to domestic fisheries since 1988. The 1989 and 1990 pollock quotas allocated for the western and central regions were 72,000 and 70,000 t, respectively. In 1989 and 1990, 6,250 t of the TAC was reserved for the Shelikof Strait area.' In both years the entire quota was taken. In 1990, the TAC was divided into four equal quarterly allocations of 17,500 t, one for each of the NPFMC regulatory areas.

In 1988, virtually all of the catch was delivered to shoreside processors, and roughly 50% of the catch was taken on the eastside of Kodiak Island in the fall. In 1989, the entire preliminary TAC was taken by the end of the first quarter. Over 50% of the 1989 preliminary TAC was taken by floating catcher-processor boats during a single 3-week period. The remainder was taken by boats working with shoreside processors. After a mid-year assessment of the status of the pollock stock, an additional 7,000 t was made available to the fishery in the fall of 1989.

Recent information on the age composition of the Gulf of Alaska pollock stock was available from the 1989 fall bottom trawl survey in the Kodiak International North Pacific Fisheries Council (INPFC) area, the 1990 spring hydroacoustic survey of Shelikof Strait, and the 1989 and the spring 1990 fisheries. Age structures were collected from fish by port samplers and domestic observers in 1989. Age-composition estimates indicate that the 1984, 1985, and 1988 year classes were predominant in 1990.

WALLEYE POLLOCK
Gulf of Alaska

Average catch (1977-90)	= 136,600 t
Long-term potential yield (MSY)	= Uncertain
Acceptable biological catch (1990)	= 100,000 t
Exploitable biomass (1990)	= 1,050,000 t
Harvesting strategy	= $F_{0.1}$
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	= Moderate and declining
Importance of recreational fishery	= Minor
Management	= Gulf of Alaska Groundfish FMP
Assessment level	= Stock synthesis (Age structured)
Status of exploitation	= Below overfishing level

M = 0.30 F_{1991} = 0.09 $F_{overfishing}$ = 0.42

The stock-synthesis model was used to assess the status of the Gulf of Alaska pollock stock in 1990. 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 INPFC statistical areas for years 1976-89. Fishery-independent data sets were incorporated into the stock assessment procedure to help calibrate the resulting abundance estimates to the appropriate population level.

Estimates of F_{MSY} and B_{MSY} are uncertain because of conflicting information regarding historical stock trends. The estimate of long-term yield derived from a dynamic pool model was 457,000 t. Estimates of long-term yield from a yield-per-recruit model at $F_{0.1}$ was 370,000 t. Application of simulation models that incorporate an asymptotic spawner-recruit relationship shows a long-term yield of approximately 176,000 t.

Projections of Gulf of Alaska pollock biomass and yield have been made for fish age 3 and older for the period 1991-93. The 1991 TAC for pollock in the western and central regulatory areas was set at 100,000 t.

Estimates of fishing mortality associated with sustainable yields may be inflated because of uncertainty regarding the stock-recruitment relationship. Therefore, the overfishing level for pollock was defined as the fishing mortality rate that resulted in the biomass-per-recruit ratio falling below 30% of the pristine level. This fishing mortality

rate was 0.416. The fishing mortality rate associated with the 1991 central and eastern TACs of 100,000 t was 0.09, well below the overfishing level.

This chapter was written by Anne B. Hollowed.

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.

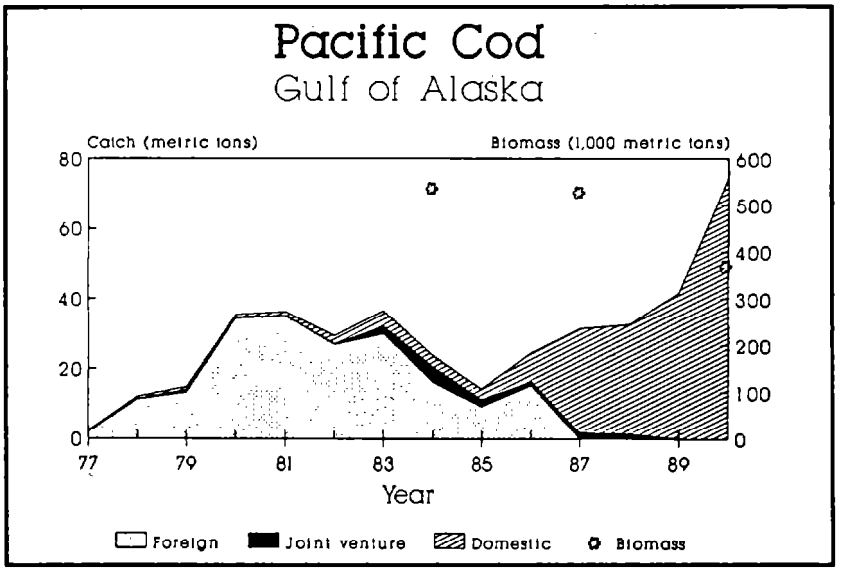
Methot, R. D. 1990. Synthesis model: An adaptable framework for analysis of diverse stock assessment data. INPFC Bull. 50:259-277.

13. PACIFIC COD

In North Pacific waters, 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 region, and eastern Bering Sea to Norton Sound. Gulf of Alaska, Bering Sea, and Aleutian Islands region Pacific cod stocks have been shown to be genetically indistinguishable. Cod movements between the Gulf of Alaska and the Bering Sea/Aleutian Islands region have been documented through tagging studies. Because the magnitude and regularity of the migrations are unknown, Gulf of Alaska and Bering Sea/Aleutian Islands cod stocks are managed as two separate units.

Gulf of Alaska Pacific cod feed on a wide variety of crustaceans and fish and rarely attain lengths greater than 95 cm or weights greater than 7 kg. Accurate ageing of Pacific cod is difficult, but maximum ages for this area appear to be about 15 years. Sexual maturity is reached between ages 3 and 5. Spawning occurs during late winter and early spring.

Total 1990 Pacific cod landings in the Gulf of Alaska increased 79% to 75,000 t, from about 42,000 t in 1989. Trawlers caught 82% of the total 1990 cod



landings; pot and longline fisheries landed about 9% each. Ex-vessel value of 1990 Gulf of Alaska Pacific cod landings increased 104% to $26.1 million from $12.8 million in 1989. Catches by recreational fisheries are not routinely reported, but the landings appear to be insignificant. The total catch of Pacific cod in the Gulf of Alaska is currently. at a historical high, comprising 34% of all Gulf groundfish landings. Foreign fisheries for Pacific cod ended in 1987. They were dominated by Japanese longline operations and peaked in 1981 at about 35,000 t. Relatively small joint venture fisheries peaked in 1984 and ended after 1988.

Groundfish trawl surveys were conducted in the Gulf of Alaska in 1984, 1987, and 1990. Estimates of exploitable Pacific cod biomass (greater than age 3) from these surveys were highest in 1984 at about 580,000 t, and declined to about 380,000 t in 1990. An exceptionally large 1977 year class was chiefly responsible for the historically high levels of cod abundance of the early 1980s. No other comparable year classes have been detected; thus, population levels should continue to decrease. Fishing mortality is fast approaching F_{MSY} and there are indications that fishing effort in the Gulf of Alaska will tend to increase in the near future. Thus, it is likely that fishing pressure and average recruitment may also cause Gulf of Alaska cod abundance to continue to decrease.

PACIFIC COD
Gulf of Alaska
COMMERCIAL CATCH (t)

Year	Foreign	JV	Domestic	Total
1977	1,987	0	270	2,257
1978	11,370	7	785	12,162
1979	13,173	711	985	14,869
1980	34,245	466	612	35,323
1981	34,969	58	1,061	36,088
1982	26,937	193	2,250	29,380
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

PACIFIC COD
Gulf of Alaska

Average catch (1977-90)	= 29,250 t
Average catch (1986-90)	= 41,000 t
Long-term potential yield (MSY)	= 39,100 t
Acceptable biological catch (1991)	= 77,900 t
Exploitable biomass (1990)	= 387,700 t
Harvesting strategy	= F_{MSY}
Age/length at recruitment	= 3 yrs/45 cm
Age/length at 50% maturity	= 5 yrs/61 cm(females)
Maximum age	= 15+ years
Abundance and trend	= Moderate & declining
Importance of recreational fishery	= Minor
Management	= Gulf of Alaska Groundfish FMP
Assessment level	= Age structured
Status of exploitation	= Fully exploited

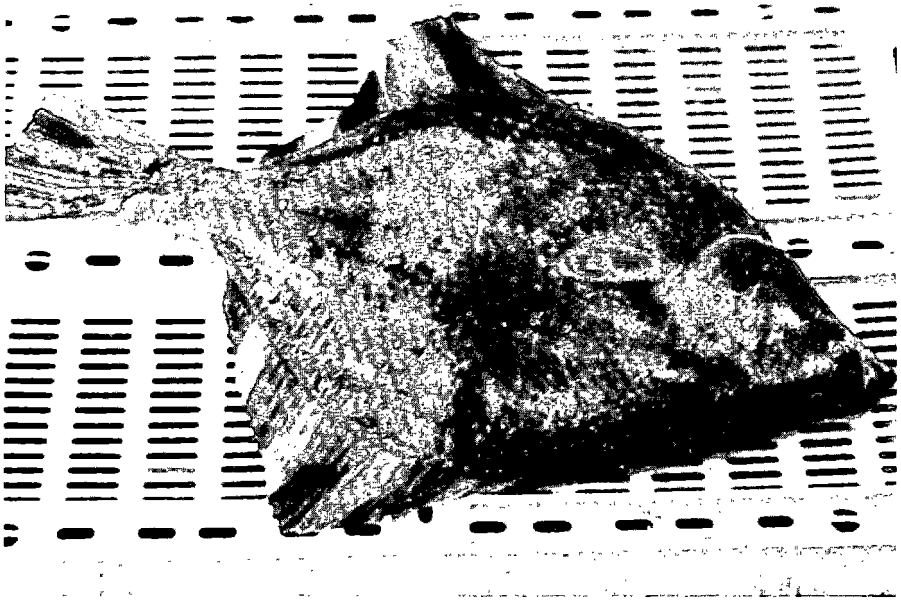
$M = 0.29$ $F_{0.1} = 0.18$ $F_{MSY} = 0.18$
$F_{overfishing} = 0.18$ $F_{1977\text{-}90\ average} = 0.05$

This chapter was written by Harold H. Zenger, Jr.

For further information

Zenger, H. H., and G. G. Thompson. 1990. Pacific cod. In Stock assessment and fishery evaluation document for the 1991 Gulf of Alaska groundfish fishery, p. 90-105. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

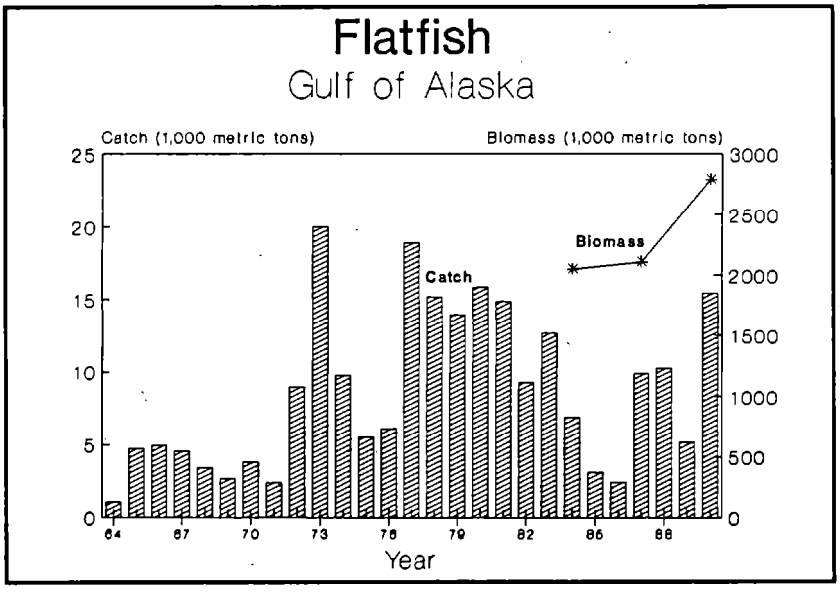
14. FLATFISH



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 (Atheresthes stomias), flathead sole (Hippoglossoides elassodon), rock sole (Lepidopsetta bilineata), rex sole (Glyptocephalus zachirus), Dover sole (Microstomus pacificus), yellowfin sole (Limanda aspera), and starry flounder (Platichthys stellatus). Gulf of Alaska flatfish are a 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 ABC limit. Flathead sole are likewise assigned a separate ABC limit because they overlap the depth distributions of the shallow- and deep-water groups.

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 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 when joint venture fishing ceased and a nearshore domestic fishery developed at Kodiak Island. Catch levels remain well below the TAC of 57,000 t for 1991.

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 indicates a continuing presence of young fish recruiting to the flatfish populations,

This chapter was written by Thomas K. Wilderbuer and Eric s. Brown.

For further information

Wilderbuer, T. K., and E. S. Brown. 1990. Flatfish. In Stock assessment and fishery evaluation document for the 1991 Gulf of Alaska groundfish fishery, p. 106-124. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

FLATFISH
Gulf of Alaska

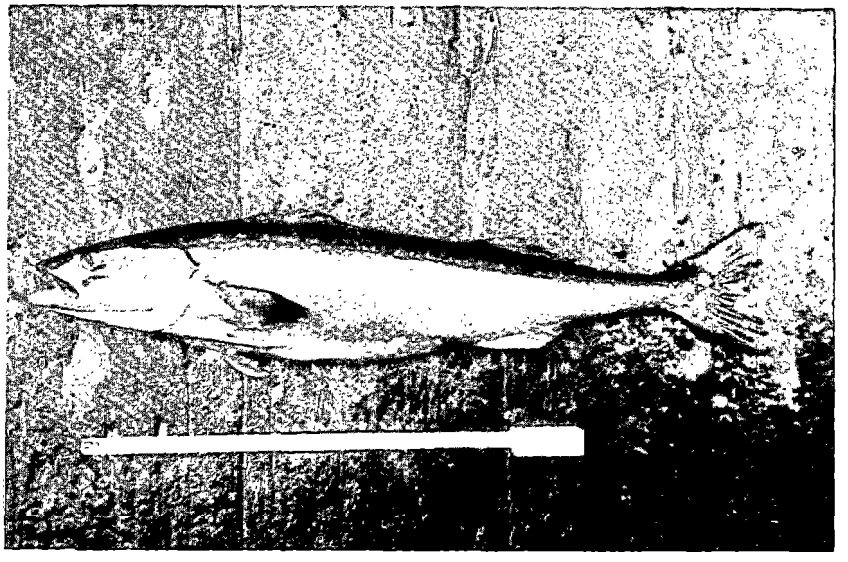
Average catch (1977-90)	= 10,500 t
Long-term potential yield (MSY)	= 169,000 t
Acceptable biological catch (1990)	= 514,900 t
Exploitable biomass (1990 survey)	= 2,750,000 t
Harvesting strategy	= $F_{0.1}$
Age/length at recruitment	= 3-4 yrs/ ?
Age/length at 50% maturity	= 5 yrs/61 cm(females)
Maximum age	= 15+ years
Abundance and trend	= High and Stable
Importance of recreational fishery	= Minor
Management	= Gulf of Alaska Groundfish FMP
Assessment level	= 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 $F_{1977-90}$ = very low

FLATFISH
Gulf of Alaska
COMMERCIAL CATCH (1,000 t)

Category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Foreign	15.5	14.4	9.0	9.5	3.0	0.2	<0.1	0	0	0
Joint venture	0.2	<0.1	<0.1	2.7	3.4	2.4	1.0	7.2	1.8	0
Domestic	0.1	0.4	0.1	0.4	0.4	0.5	1.4	2.7	8.5	5.2
Total	15.8	14.9	9.2	12.6	6.8	3.1	2.4	9.9	10.3	5.2

15. SABLEFISH



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 Siberian and Kamchatkan coasts of the U.S.S.R. to the northeast coast of Japan. For management purposes, the sablefish resource is divided into 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.

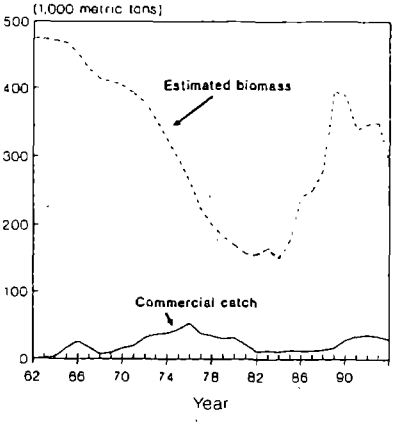
Eggs, larvae, and young-of-the-year juveniles are pelagic, but older juveniles and adults are demersal. Sablefish have a wide depth distribution--young juveniles are found in surface and near-shore waters down to depths of 150 m, older juveniles are found on or near the bottom in water 100-200 m in depth, and adults are found in water 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 greater than 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 expansion of the Japanese longline fleet, which began operations in the eastern Bering Sea in 1958. The fishery rapidly expanded in this area and catches peaked at 26,000 t in 1962. The longline fleet then expanded to the Aleutian Islands 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, 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 catches in the eastern Bering Sea/Aleutian Islands and Gulf of Alaska in 1990 were 31,800 t valued at $49 million (ex-vessel value). This species is of minor recreational importance.

Historic biomass estimates, as determined by stock-reduction analysis, revealed declining stock sizes through 1978. During these years, the stock was heavily exploited by foreign fisheries. Estimates of exploitable biomass after 1979 were determined by scaling relative biomass indices from an annual longline survey to

Sablefish
Gulf of Alaska, Bering Sea, and Aleutian Islands



estimates of absolute biomass based on comparisons of longline and bottom trawl survey catch rates. Stock abundance increased after 1980, peaking 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 showing 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 good condition. Sablefish are fully utilized and are harvested under an $F_{0.1}$ strategy.

This chapter was written by Sandra A. Lowe and Jeffrey T. Fujioka.

For further information

Fujioka, J. T. 1990. Sablefish. In Stock assessment and fishery evaluation report for the 1991 Gulf of Alaska groundfish fishery, p. 125-139. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, AK 99510.

Lowe, S. A. 1990. Sablefish. In Stock assessment and fishery evaluation document for groundfish resources in the -Bering Sea/Aleutian Islands region as projected for 1991, p. 142-161. North Pacific Fisheries Management Council, P.O. Box 103136, Anchorage, AK 99510.

Lowe, S. A., J. T. Fujioka, and J. M. Terry. In press. Bioeconomic analysis of a minimum size limit for Gulf of Alaska sablefish using a yield per recruit model. Fish. Research.

SABLEFISH
Bering Sea, Gulf of Alaska, and Aleutian Islands

Average catch (1977-90)	= 21,000 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1990)	= 28,800 t
Exploitable biomass (1991)	= 248,000 t
Harvesting strategy	= $F_{0.1}$
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	= Gulf of Alaska and Bering Sea-Aleutians Groundfish FMP
Assessment level	= 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 $F_{1979\text{-}90\ average}$ = 0.08

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

Category	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Eastern Bering Sea										
Foreign	2.6	3.0	2.6	1.2	0.2	0.1	0.0	--	--	--
Joint venture	0.0	0.0	0.0	0.1	0.0	0.3	0.1	0.0	0.0	--
Domestic	0.0	0.2	0.1	1.0	2.1	3.1	4.1	3.2	1.2	2.3
Subtotal	2.6	3.2	2.7	2.3	2.3	3.5	4.2	3.2	1.2	2.3
Aleutian Islands										
Foreign	0.4	0.8	0.6	0.7	0.1	--	--	--	--	--
Joint venture	0.2	0.1	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	2.1
Subtotal	0.6	0.9	0.7	1.0	1.5	3.0	3.9	3.4	3.2	2.1
Gulf of Alaska										
Foreign	8.0	5.6	5.0	1.1	0.0	0.0	--	--	--	--
Joint venture	0.0	0.0	0.0	0.5	0.2	0.0	0.2	0.0	--	--
Domestic	1.9	2.9	3.8	8.6	12.2	21.6	26.1	29.9	29.8	25.7
Subtotal	9.9	8.5	8.8	10.2	12.4	21.6	26.3	29.9	29.8	25.7
Total	13.1	12.6	12.2	13.5	16.2	28.1	34.4	36.5	34.2	30.1

16. SLOPE ROCKFISH

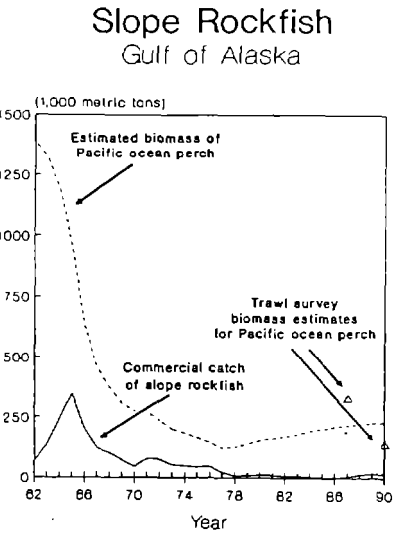
The NPFMC presently classifies 18 Gulf of Alaska rockfish species (genus Sebastes) in the slops rockfish assemblage. Slope rockfish are defined as those species of *Sebastes* that as adults inhabit offshore waters of the outer continental shelf and continental slope, generally in depths greater than 150-200 m. Trawl surveys of the Gulf of Alaska indicate that six species of slope rockfish together comprise an estimated 99% of the total biomass for the assemblage: Pacific ocean perch *(Sebastes* alutus), northern rockfish *(S. polyspinis),* rougheye rockfish (S. *aleutianus),* sharpchin rockfish (S. zacentrus), harlequin rockfish (S. variegatus), and shortraker rockfish *(S. borealis).* The remaining 12 species appear to have a relatively sparse distribution in the Gulf of Alaska.

Of the six 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.

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 Pacificcoast of the U.S.S.R. 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. Age of recruitment is 9 years, when the fish are approximately 35 cm in length. 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 overexploitation, 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 have increased annually since then. The 1990 catch of 20,705 t was the highest since 1977, and its ex-vessel value was estimated at $8.7 million. The increased catches are related to both a substantial increase in effort by the domestic fleet, and to higher levels of TAC implemented by the NPFMC. Pa-



cific ocean perch is presumed to be the major species caught. Recent fisheries also target on shortraker and rougheye rockfish, two larger sized species that inhabit deeper waters of the continental slope.

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 stock, based primarily on trawl surveys, showed that the stock was still low but starting to increase. The current stock condition is uncertain, although it is still thought to be very depressed compared to its former (pre-1960) abundance. The best estimate of current exploitable biomass of 232,000 t is based on the average of the 1987 and 1990 surveys.

Beginning in 1991, the NPFMC has divided the assemblage into three subgroups: Pacific ocean perch, shortraker-rougheye, and other slope rockfish for management. Separate ASCs and TACs are now assigned to each subgroup. The subgroups are currently managed under an F = M harvesting strategy.

This chapter was written by David M. Clausen and Jonathan Heifetz.

For further information

Heifetz, J., and D. M. Clausen. 1990. Slope rockfish. In Stock assessment and fishery evaluation report for the 1991 Gulf of Alaska groundfish fishery, p. 140-161. North Pacific Fishery Management Council, P.O. Box, 103136, Anchorage, AK 99510.

SLOPE ROCKFISH
Gulf of Alaska
COMMERCIAL CATCH (1,000 t)

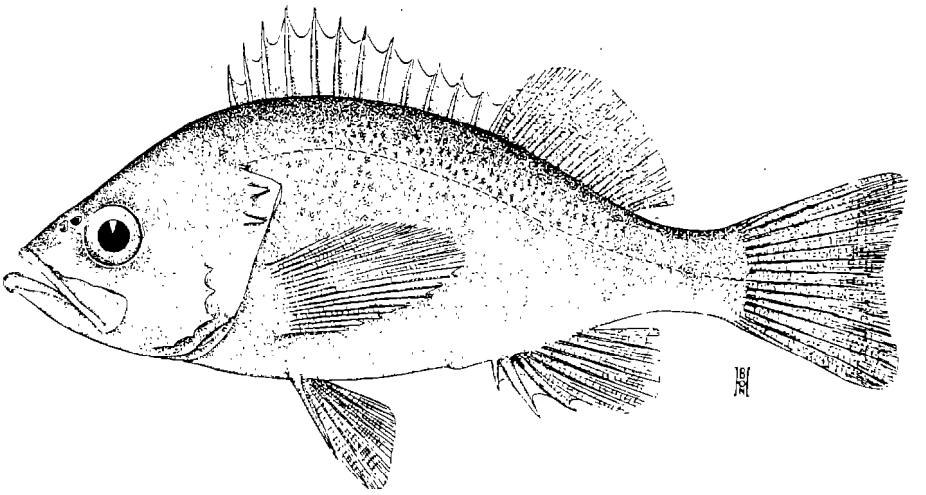
Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Domestic	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.8	2.9	4.9	13.8	19.0
Foreign	23.4	8.2	9.7	12.4	12.2	8.0	5.4	2.6	<0.1	<0.1	-	-	-
Joint venture	-	-	0.1	<0.1	<0.1	<0.1	2.0	1.7	0.3	<0.1	0.1	<0.1	-
Total	23.5	8.2	9.9	12.5	12.2	8.0	7.4	4.5	1.1	3.0	5.0	13.8	19.0

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

Average catch (1977-89)	= 9,837 t (includes other species of slope rockfish)
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1991)	= 5,800 t (17,900 t for assemblage)
Exploitable biomass (1990)	= 231,894 t (505,587 t for assemblage)
Fishing strategy	= F = M
Age/length at recruitment	= 9 years/35.1 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	= Gulf of Alaska groundfish FMP
Assessment level	= Yield-per-recruit/stock-reduction analysis
Status of exploitation	= Unknown

$M = 0.05$ $F_{0.1} = 0.08$ F_{MSY} = Unknown
$F_{overfishing} = 0.025$ $F_{1977\text{-}89\ average} = 0.05$

17. PELAGIC SHELF ROCKFISH



Dusky rockfish

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. Throughout the Gulf of Alaska, dusky rockfish *(Sebastes ciliatus)* is the most abundant species in the assemblage. Recent trawl surveys have shown this species to comprise 93-99% 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. Natural mortality rate (M) is also unknown but, in common with other species of Sebastes, it is assumed to be relatively low (less than 0.10). Dusky rockfish attain a maximum length of 50 cm.

Catch statistics for pelagic shelf rockfish in the Gulf of Alaska are only available beginning in 1988 when this management group was created. The catches in 1988 (1,100t) and 1989 (1,700 t) were much less than the assigned TAC, indicating the assemblage has been underutilized by commercial fishermen. Nearly all the catch is taken in bottom trawls.

The only stock-assessment information on pelagic shelf rockfish comes from bottom trawl surveys of the Gulf of Alaska. In the 1987 survey, exploitable biomass of dusky rockfish was estimated at 164,352 t, the third highest among all Gulf species of *Sebastes.* Two prominent year classes of dusky rockfish, from

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

	Gulf of Alaska Areas			
	Western	Central	Eastern	Total
1988	400	518	168	1,086
1989	113	888	737	1,738
1990	165	955	527	1,647

1976 and 1980, comprised much of the biomass. In the 1990 survey, however, exploitable biomass decreased to 28,309 t. A decline of this magnitude does not seem likely when one considers the assumed low natural mortality rate for the assemblage and the relatively small commercial catches. One hypothesis is that some portion of the population may have moved off bottom in 1990 and, hence, was not captured in the survey. Thus, present stock condition of pelagic shelf rockfish is unknown, 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. Because M is unknown for dusky rockfish, M for another rockfish species, Pacific ocean perch (M = 0.05), is used. This exploitation rate is then applied to the estimate of exploitable biomass from the trawl surveys to determine ABC. Due to the uncertainty of the trawl survey results in 1987 and 1990, the average of the exploitable biomass estimates from the two trawl surveys (96,330 t) is presently used for these computations.

This chapter was written by David M. Clausen and Jonathan Heifetz.

For further information

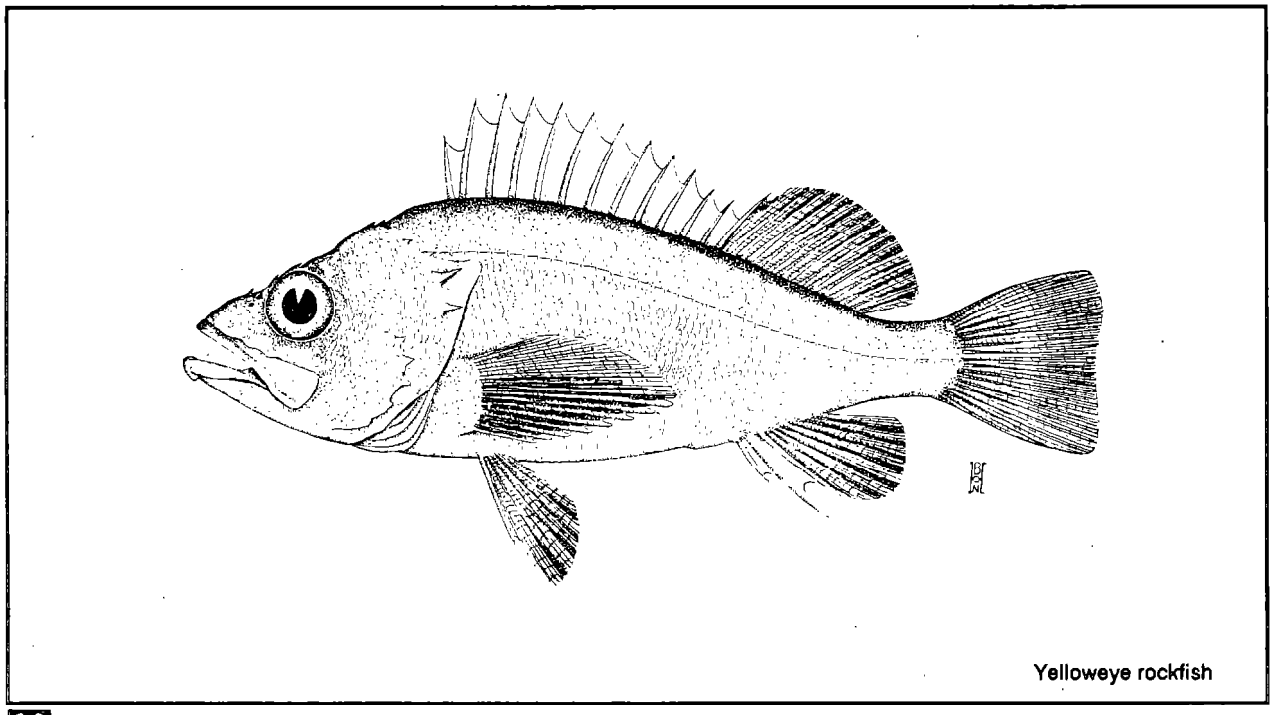
Clausen, D. M., and J. Heifetz. 1990. Pelagic shelf rockfish. In Stock assessment and fishery evaluation report for the 1991 Gulf of Alaska groundfish fishery, p. 162-168. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

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

Average catch (1988-89)	= 1,412 t (includes other species of pelagic shelf rockfish)
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1991)	= 4,800 t
Exploitable biomass (1990)	= 96,330 t
Harvesting strategy	= F = M = 0.05 (assumed rate)
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	= Gulf of Alaska Groundfish FMP
Assessment level	= Trawl survey
Status of exploitation	= Under-exploited

M = Unknown $F_{0.1}$ = Unknown F_{MSY} = Unknown
$F_{overfishing}$ = Unknown $F_{1979\text{-}89\ average}$ = Unknown

18. DEMERSAL SHELF ROCKFISH



Yelloweye rockfish

The demersal shelf rockfish assemblage includes about 10 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 under 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 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 from 1982 to 1989, as required by the NPFMC overfishing definition.

Quillback and yelloweye rockfish, the latter being the primary target species, account for 18 and 78% of the landed weight in the 1989 rockfish longline fishery, respectively. Demersal shelf rockfish are also taken as bycatch in the longline fishery for Pacific 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.

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. Most Southeast Alaskan processors limit trip time to 4 days. The progressive expansion to more distant fishing grounds is considered to be a strong indication that abundance has declined near the major ports. No estimate has been made on the absolute abundance of stocks of demersal shelf rockfish.

This chapter was written by Victoria M. O'Connell and Jeffrey T. Fujioka.

For further information

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 (editor), Proceedings of the International Rockfish Symposium. p. 171-185. Alaska Sea Grant Report No. 87-2.

O'Connell, V. M., and B. E. Bracken., 1990. Demersal shelf rockfish. In Stock assessment and fishery evaluation report for the 1991 Gulf of Alaska groundfish fishery. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

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

DEMERSAL SHELF ROCKFISH
Gulf of Alaska
COMMERCIAL CATCH (t)

Category	1982	1983	1984	1985	1986	1987	1988	1989	1990
Directed	106	161	543	388	449	726	505	310	199
Incidental	14	15	20	100	41	47	53	103	128
Total	120	176	563	488	491	773	558	413	327

DEMERSAL SHELF ROCKFISH COMPLEX
Gulf of Alaska

Average catch (1988-89)	= 429 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1991)	= 445 t
Exploitable biomass (1990)	= Unknown
Harvesting strategy	= Accommodate directed and bycatch fishery needs
Age/length at recruitment	= 20 years/51-54 cm (Sebastes ruberrimus)
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	= Gulf of Alaska Groundfish FMP and State of Alaska
Assessment level	= Yield-per-recruit with no abundance index
Status of exploitation	= Local depletions

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

(Values for M and F above are for S. ruberrimus)

19. THORNYHEADS

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 in depths ranging from 300 to 700 m. They 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 NPFMC's Gulf of Alaska groundfish FMP. Catches were made exclusively by foreign fisheries in the late 1970s and early 1980s and were less than 1,400 t. With the decrease in the foreign quota in the Gulf, catches decreased in the mid- 1980s before peaking in 1989 at 3,079 t due to the growth of the domestic fishing industry. Catches decreased 46% from 1989 to 1990. In 1990, the ex-vessel value of the catch was $1.4 million.

Based on trawl survey data in the Gulf of Alaska, abundance of thornyheads has sharply declined from 123,009 t in 1984 to 99,000 t in 1987, and to 26,009 tin 1990. Since abundance of thornyheads was first measured in 1984, landings have never exceeded 6.5% of the best interpolated estimate of biomass, while from 1984 to 1988, landings did not exceed 4%.

This chapter was written by Pierre K. Dawson.

For further information

Dawson, P. K. 1990. Thornyheads. In Stock assessment and fishery evaluation report for the 1991 Gulf of Alaska groundfish fishery, p. 184-205. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage, AK 99510.

SHORTSPINE THORNYHEADS
Gulf of Alaska

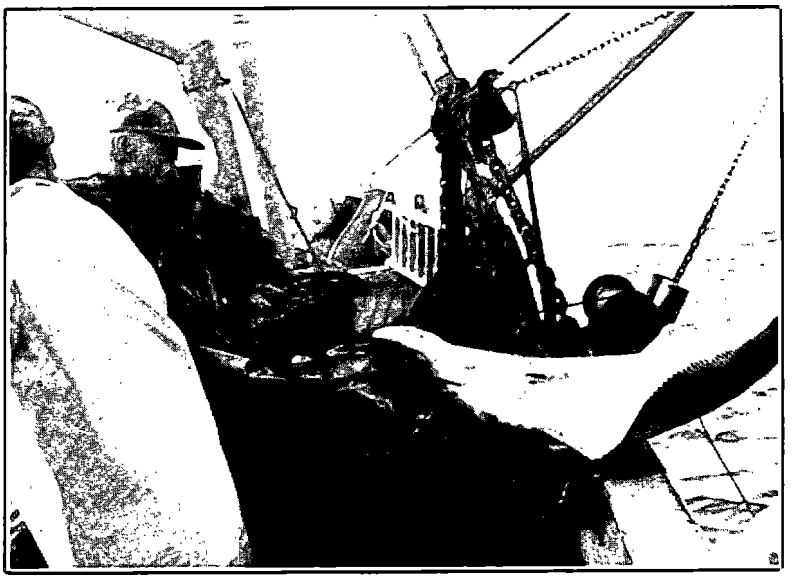
Average catch (1980-90)	= 1,226 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1991)	= 1,798 t
Exploitable biomass (1990)	= 25,700 t
Harvesting strategy	= F = M
Age/length at recruitment	= 16 yrs/25 cm
Maximum age	= 62+ yrs
Abundance and trend	= Low and declining
Importance of recreational fishery	= Minor
Management	= Gulf of Alaska groundfish FMP
Assessment level	= Yield-per-recruit
Status of exploitation	= Fully exploited

$M = 0.07$ $F_{0.1} = 0.07$ $F_{MSY} = 0.05$ $F_{1990} = 0.06$
$F_{overfishing} = 0.07$ $F_{1984,87,90\ average} = 0.03$

SHORTSPINE THORNYHEADS
Gulf of Alaska
COMMERCIAL CATCH (t)

Category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Domestic	0	0	0	0	24	69	713	1,943	2,787	3,079	1,646
Foreign	1,351	1,340	787	716	165	4	0	0	0	0	0
Joint venture	0	0	0	13	19	9	1	20	0	0	0
Total	1,351	1,340	787	729	208	82	714	1,963	2,787	3,079	1,646

20. PACIFIC HALIBUT



The Pacific halibut, Hippoglossus stenolepis, is the largest member of the flounder family Pleuronectidae with males weighing up to 54 kg (120 pounds) and females weighing up to 230 kg (500 pounds). 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.

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 1800 feet of groundline, with gangions attached every 18 feet. 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 6,500 vessels were commercially licensed to operate in 1990, while in Canada 435 vessels were eligible to fish.

In 1990, nearly 37,000 t of Pacific halibut were landed by the commercial longline fishery: 31,900 t in the United States and 5,100 t in Canada, with a total ex-vessel value of $115 million

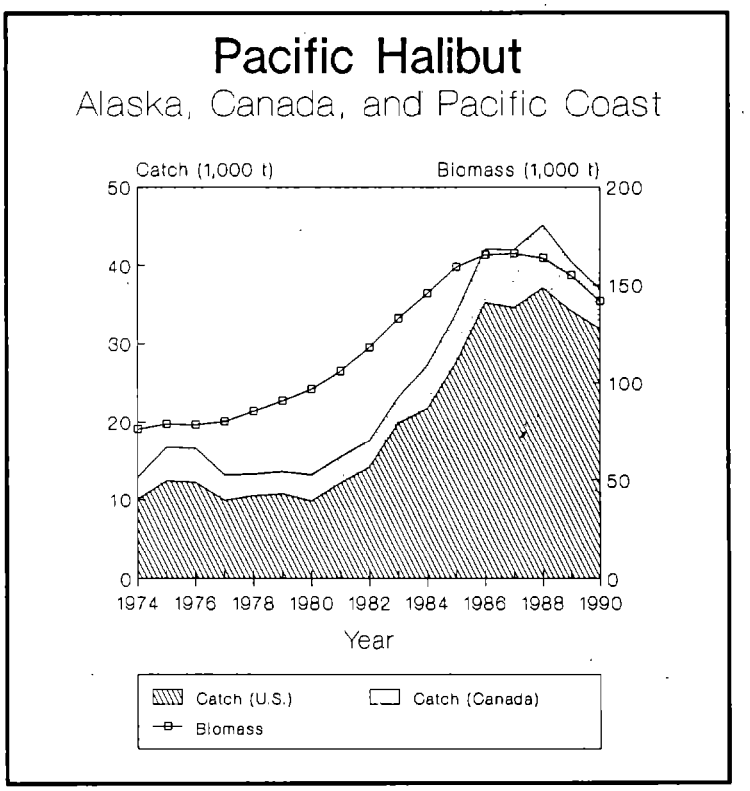
PACIFIC HALIBUT
Alaska and the Pacific Coast
COMMERCIAL CATCH (1,000 t)

Category	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Recreational	0.5	0.7	0.8	1.0	1.1	1.6	2.0	2.2	3.1	3.5	3.7
Commercial											
U.S.	9.8	12.1	14.2	19.9	21.7	27.6	35.3	34.6	37.2	34.2	31.9
Canada	3.4	3.4	3.4	3.3	5.5	6.3	6.8	7.4	7.8	6.3	5.1
Total	13.7	16.2	18.4	24.2	28.3	35.5	44.1	44.2	48.1	44.0	40.7

(U.S.). The 1990 harvest reflects an 8% drop in yield from the 40,000 t of Pacific halibut commercially landed in 1989. Other removals of Pacific halibut in 1990 include 3,700 t landed by recreational fisheries, 2,000 t wastage due to gear loss and discard, and 10,000 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 166,000 t in 1986 and 1987 after a period of stock rebuilding. The population has declined since that time at an average rate of 5% per year. Strong 1977 and 1979 year classes contributed to this buildup of the stock with weaker year classes subsequently contributing to the decline.

Research on optimal exploitation strategies indicates that a constant 35% 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 fishing mortality rate of 0.33 on the fully exploitable stock or a 0.16 to 0.19 rate for all 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 0.13 during the years 1974 through 1985. More recently, the fishing mortality rate has increased to an average of 0.21. 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

Average catch (1977-90)	= 27,000 t
Long-term potential yield (MSY)	= 30,000-36,000 t
Exploitable biomass (1990)	= 141,920 t
Abundance and trend	= High and stable
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 level	= Age structured

M = 0.20 $F_{0.1}$ = 0.16 F_{MSY} = 0.22 F_{1990} = 0.19

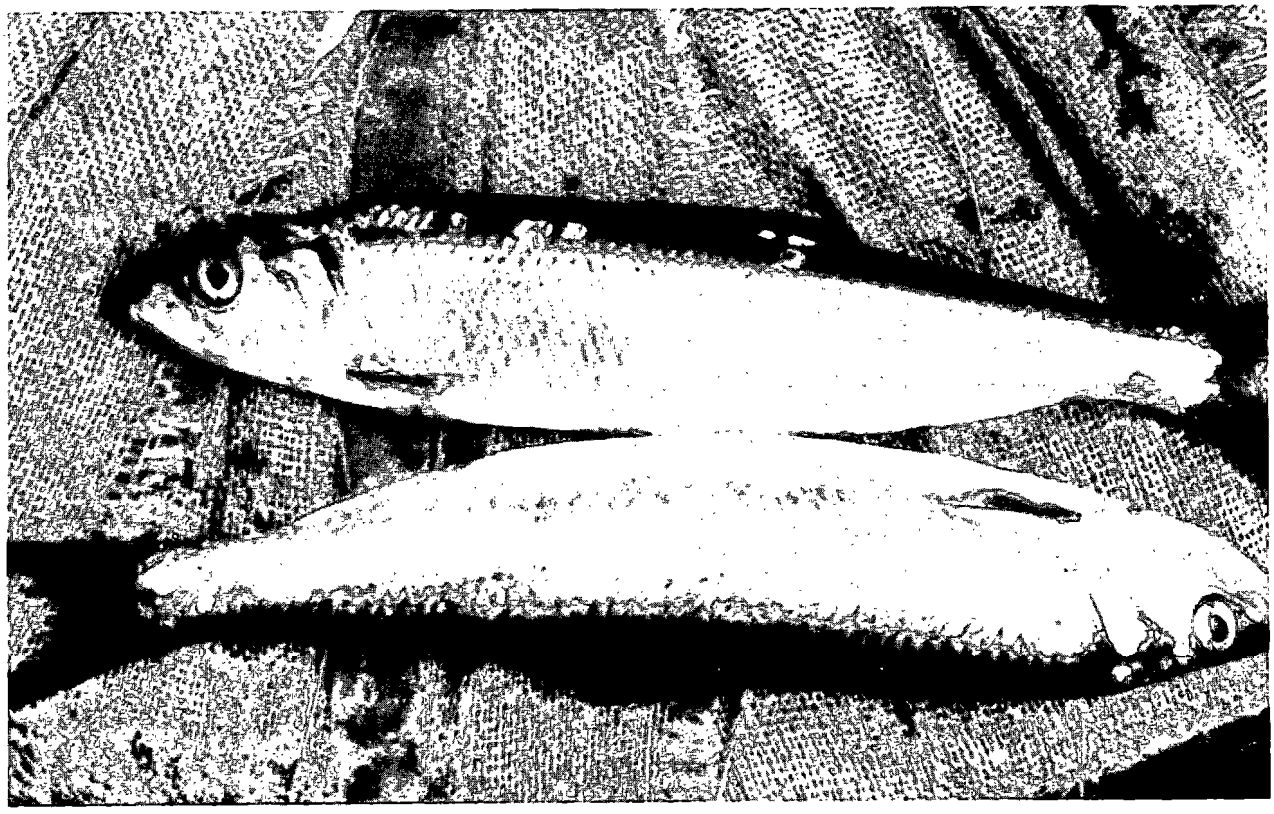
This chapter was written by Patrick J. Sullivan of the International Pacific Halibut Commission.

For further information

International Pacific Halibut Commission. 1987. The Pacific halibut: Biology, fishery, and management. IPHC Technical Report No. 22., 59 p. Int. Pacific Halibut Comm., P.O. Box 95009, Seattle, WA 98145-2009.

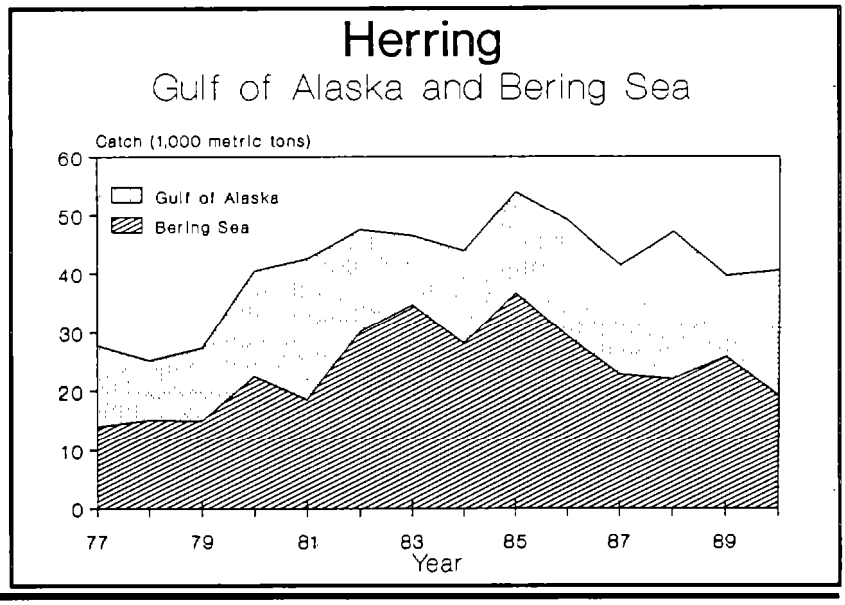
International Pacific Halibut Commission., 1990. Annual Report, 1990. 40 p. Int. Pacific Halibut Comm., P.O. Box 95009, Seattle, WA 98145-2009.

21. PACIFIC HERRING



The Pacific herring (Clupea harengus pallasi) occurs throughout the Gulf of Alaska, and Bering and Chukchi Seas and has 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 Southeast 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 by foreign fisheries from 1959 to 1980. In 1980, 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 spawning in the Togiak area, however, mature at age 4 and a maximum age of 18 years has been observed.

Naturalmortality 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), herringgrow 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 AUF&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 1990, 40,655 t of herring were harvested in Alaska with a total ex-vessel value of $27 million. The majority of the harvest was roe herring (34,459 t) and the remainder was food and bait herring (6,196 t) and roe on kelp (397 t).

Gulf of Alaska

Herring harvests in the Gulf of Alaska have averaged 18,000 t since 1977. Southeast Alaska and Prince William Sound roe-herring

PACIFIC HERRING
Gulf of Alaska and Eastern Bering Sea

	Gulf of Alaska	Bering Sea
Average catch (1977-89)	18,154 t	23,848 t
Long-term potential yield	Unknown	Unknown
Acceptable biological catch (1991)	28,201 t	16,860 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	ADF&G	ADF&G*
Assessment method	Survey, age-structured	Aerial survey
Status of exploitation	Fully utilized	Fully utilized
M	0.45	0.27

* Alaska Department of Fish and Game

fisheries have accounted for the bulk of the Gulf of Alaska catch. Catches in the Kodiak Island area have been relatively stable in recent years--near 2,000 t. Cook Inlet catches increased in the late 1980s with the occurrence of strong year classes, but catches have declined in recent years.

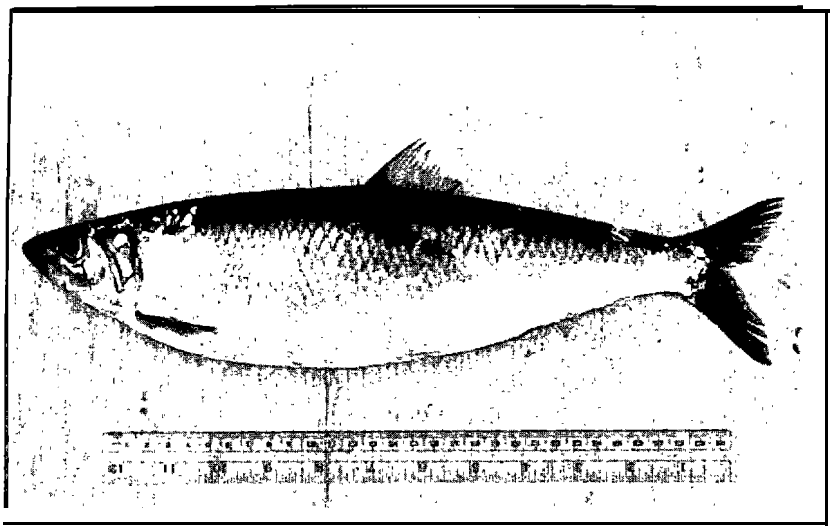
Bering Sea

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.

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 averaged 2,000-4,000 t in the foreign and joint venture fisheries, but there are indications that bycatch may have risen to higher levels in the domestic trawl fishery.

PACIFIC HERRING
Alaska
COMMERCIAL CATCH (t)

YEAR	Gulf of Alaska	Bering Sea
1980	17,346	22,382
1981	24,294	18,590
1982	18,490	30,131
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



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 they 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. Also, a very strong 1988 year class is reported in Southeast Alaska and Prince William Sound and is expected to further increase the abundance of herring in the Gulf of Alaska in 1992.

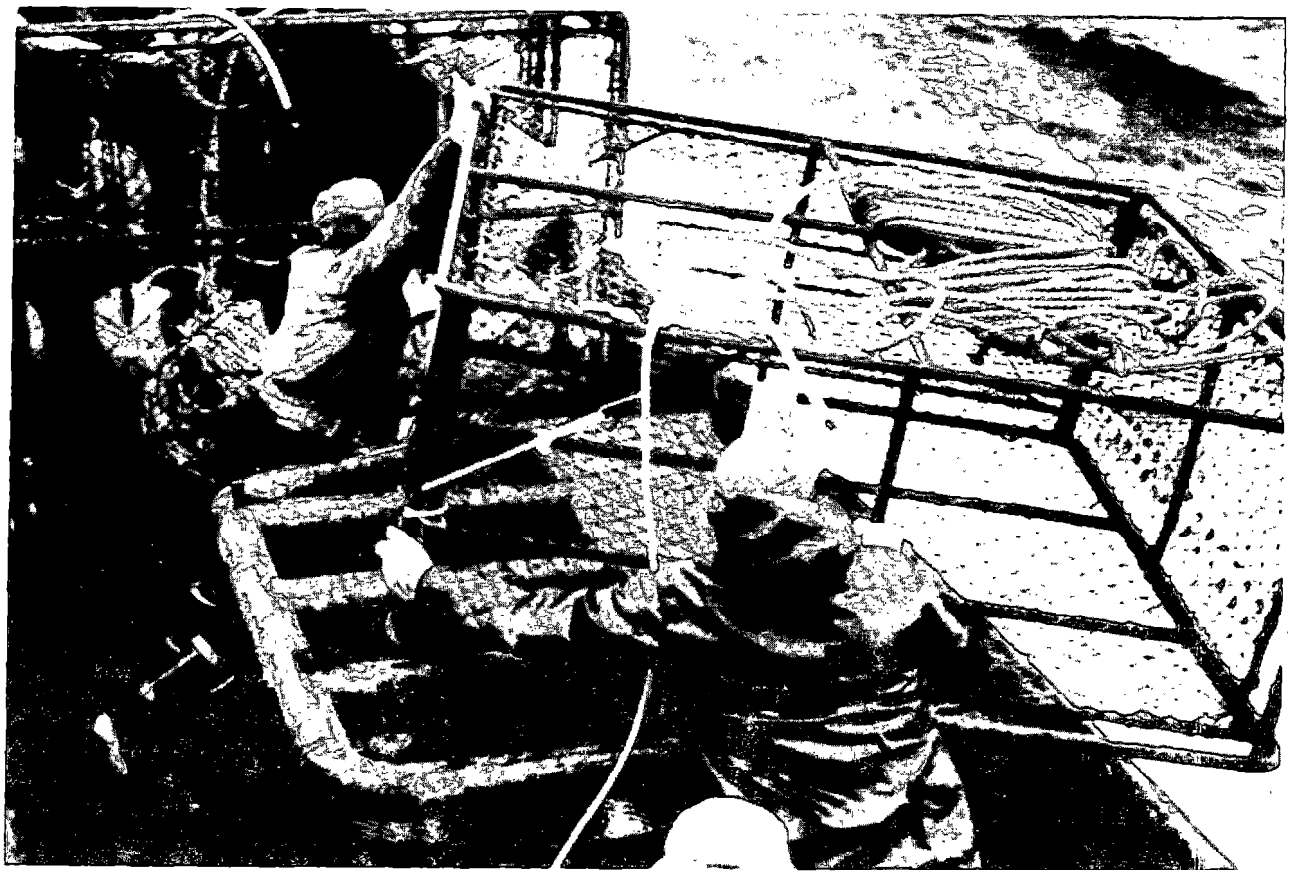
In the southeastern Bering Sea, the abundance of herring has been declining, although abundance is stable or increasing in the northeastern Bering Sea. The 1977-78 year classes were very strong and have sustained the fisheries through the 1980s. Historically, a strong year class has occurred at 5-6 year intervals, but none has occurred in the 1980s. Unless recruitment improves in the near future, stock declines are expected to continue in spawning areas south of Norton Sound. A continuing decline will affect native subsistence and inshore roe fisheries and curtail the Bering Sea groundfish fishery if herring bycatch is high.

This chapter was written by Vidar G. Wespestad.

For further information

Funk, F. 1991. Preliminary forecasts of catch and stock abundance for 1991 Alaska herring fisheries. Regional Information Rep. No. 5J91-03, 109 p. Alaska Department of Fish and Game, 333 Raspberry Road., Anchorage, AK 99518.

SHELLFISH RESOURCES



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 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. The ADF&G and the 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 Management Plan.

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). 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.

The following chapters on shellfish resources in Alaska were written by Jerry E. Reeves and members of the Crab Fishery Management Plan Team

22. KING CRABS

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.

Red King Crab

Bed king crabs are distributed in the shelf waters of the North Pacific and Bering Sea from the Japan Sea to northern British Columbia; and they 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 (4.7 in) and 90 mm (3.5 in) carapace lengths, respectively. Corresponding approximate ages of maturity are 6 and 5 years.

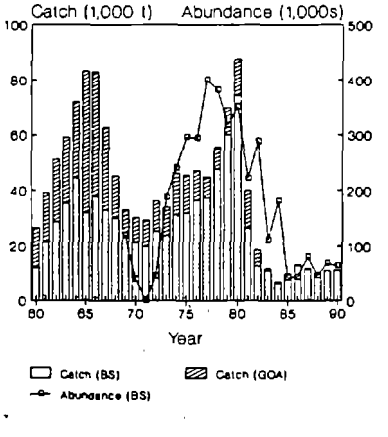
Four stocks of red king crabs are identified for management in the Bering Sea/Aleutian Islands region: the Bristol Bay, Norton Sound, Dutch Harbor, and Adak stocks. Fisheries are conducted primarily in the fall and winter. Red king crab landings increased 84% from 5,283 t in 1989 to 9,699 t in 1990, and value increased 85% from $56.7 million in 1989 to $105.1 million in 1990. All stocks are at low levels of abundance compared to historic levels.

Bristol Bay stock -- The 1990 catch of red king crab in Bristol Bay increased 98% over 1989 (4,672 t to 9,236 t), but it remained below average for this stock and substantially below the record high production of 59,000 t in 1980. Effort by 240 vessels making 331 landings during the 1-13 November season increased 26% over 1989 (208,684 to 262,131 pot lifts). Catch per unit effort (CPUE, legal crabs per pot lift) increased 50% (8 to 12) but remained below average.

The 1990 NMFS summer survey indicated that abundance remained similar to the 1989 level. The abundance of males greater than 109 mm carapace length and females greater than 89 mm carapace length, corresponding approximately to the mature stock, was 37 million male crabs in 1990 compared to 38 million male crabs in 1989. The stock of legal males declined from 12 million in 1989 to 9 million in 1990. Prerecruit male abundance in 1990 was similar to the 1989 level at 10 million crabs, and has been without a, definite trend in recent years. The abundance of mature females has likewise remained trendless 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 192 t were landed. The 1996 trawl survey conducted by the Alaska Department of Fish

King Crab
Bering Sea and Gulf of Alaska



and Game (ADF&G) indicated a low level of abundance for this stock. Based on the continuing low stock condition observed in both 1987 and 1990 ADF&G surveys, the fishery remained closed in 1990.

Adak stock -- The 1990 preliminary catch of red king crabs at Adak decreased 25% from 1989 (499 to 376 t), and it remained below high production levels of the 1960s and 1970s. Effort by 10 vessels making 332 landings during the 1 November-15 February season decreased 81% over 1989 (54,513 to 10,573 pot lifts). Catch per unit effort increased from 4 to 14 legal crabs per pot lift. 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 1990, based on analysis of fishery CPUE, was below F_{MSY}.

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

YEAR	Bristol Bay	Dutch Harbor	Adak	Norton Sound	TOTAL
1981	15,241	2,338	748	635	18,962
1982	1,361	196	772	91	2,420
1983	0	0	899	181	1,080
1984	1,905	0	620	181	2,706
1985	1,905	0	411	181	2,497
1986	5,171	0	323	227	5,721
1987	5,579	0	551	136	6,266
1988	3,357	0	711	91	4,159
1989	4,672	0	499	112	5,283
1990	9,236	0	376	87	9,699

Norton Sound stock The 1990 catch of red king crab in Norton Sound decreased 34% from 1989 (119 to 79 t), and was below the recent-year average. Effort by 10 vessels making 5 landings during the 1990 season decreased 50% over 1989. There were 5,149 pot lifts in 1989 and 3,255 pot lifts in 1990. Catch per unit effort increased 19% (16 to 19 legal crabs per pot lift).

This stock was last surveyed in 1988 by NMFS. Results indicate a population of mature crabs of

RED KING CRAB
Bering Sea/Aleutians Region

		Bristol Bay	Dutch Harbor	Adak	Norton Sound
Long-term potential catch (t)		15,876	5,080	3,175	454
Importance of non-commercial fishery		Minor	Minor	Minor	Minor
Management		State/ Fed.FMP	State/ Fed.FMP	State/ Fed.FMP	State/ Fed.FMP
Status of exploitation[1]		Fully-Exploited	Fully-Exploited	Fully-Exploited	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 level		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(90)		0.24	0.00	0.26	0.02

[1] Fully exploited status includes socioeconomic factors

2.5 million, close to the 2.7 million estimated in 1985. Fishing mortality in 1990 was below F_{MSY}.

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 (4.7 in) and 90 mm (3.5 in) carapace length, respectively. Blue king crabs of the St. Matthew Island stock are smaller. The fishery is managed with a minimum size limit of 140 mm (5.5 in) 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 48% in 1990 (529 to 783 t), with commercial value increasing 62% ($3.4 to $5.5 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 1990 NMFS summer survey indicated that abundance of the mature stock increased in 1990, but still remains at a relatively low level. Males greater than 109 mm carapace length and females greater than 89 mm carapace length, corresponding approximately to the mature stock, increased to 4.3 million crabs in 1990 compared to 1.6 million in 1989. The stock of legal males remained similar between years. Prerecruit male abundance increased noticeably in 1990. The abundance of mature males, considered an index of spawners, increased over 1989. The stock has been at a depressed level since 1984 but, as indicated by prerecruit abundance, is now showing early signs of recovery.

St. Matthew Island stock -- The 1990 blue king crab catch around St. Matthew Island increased 32% over 1989 (529 to 783 t), but remained below average and sub-

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

Year	Pribilofs	St. Mathews	Total
1981	4119	2099	6218
1982	1998	4012	6010
1983	995	4288	5283
1984	139	1708	1847
1985	242	1101	1343
1986	117	455	572
1987	318	488	806
1988	0	601	601
1989	0	529	529
1990	0	783	783

BLUE KING CRAB
Bering Sea/Aleutians Region

		Pribilofs	St. Mathews
Long-term potential catch (t)		1,814	1,361
Importance of non-commercial fishery		Minor	Minor
Management		State/ Fed.FMP	State/ Fed.FMP
Status of exploitation[1]		Fully-Exploited	Fully-Exploited
Age at 50% maturity		Unknown	Unknown
Size at 50% maturity	males	120	105
Carapace length(mm)	females	90	80
Assessment level		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(90)		0.00	0.18

[1] Fully exploited status includes socioeconomic factors

stantially below the high production years 1982 and 1983. Effort by 31 vessels making 38 landings during the 1-7 September season decreased 15% from 1989 (30,853 to 26,264 pot lifts). Catch per unit effort increased 88% (8 to 15 legal crabs per pot lift). The 1990 NMFS summer survey indicated that abundance remained similar to the 1989 level. The abundance of males greater than 104 mm carapace length and females greater- than 79 mm carapace length, corresponding approximately to the mature stock, was 2.6 million crabs in 1990 compared to 4.2 million in 1989. The stock of legal males, 1.5 million crabs in 1989, was 1.7 million in 1990. Prerecruit male abundance was 0.8 million in 1990, compared to 1.0 million in 1989. The abundance of mature males, used as an index of the spawning stock, Was 2.4 million in 1990 compared to 2.5 million in 1989. Fishing mortality on the mature male stock in 1990 was below F_{MSY}.

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

YEAR	Adak	Dutch Harbor	Pribilof	Northern	TOTAL
1981	542	2	c	0	594
1982	3,632	537	32	88	4,289
1983	3,687	821	388	0	4,896
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	4,600	780	0	0	5,380

c = confidential data

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 most management areas the min-

BROWN KING CRAB
Bering Sea/Aleutians Region

		Adak	Dutch Harbor	Pribilof	Northern
Long-term potential catch (t)		3,357	635	0	37
Importance of non-commercial fishery		Minor	Minor	Minor	Minor
Management		State/ Fed.FMP	State/ Fed.FMP	State/ Fed.FMP	State/ Fed.FMP
Status of exploitation[1]		Over-Exploited	Over-Exploited	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(90)		0.73	1.03	0	0

[1] Fully exploited status includes socio-economic factors

imum 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 carapace length 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; data from the 1990-91 fishery are still incomplete. Brown king crab landings increased 11% from 1988-89 to 1989-90 (4,893 to 5,450 t), but value decreased 6% from $39.2 to $37.0 million.

Adak stock -- The 1989 brown king crab catch from Adak increased 12% over 1988 (4,119 to 4,610 t). Effort by 64 vessels making 505 landings during the 1 November-15 August season increased 15% over 1988 (280,732 to 324,153 pot lifts). Catch per unit effort remained the same at eight legal crabs per pot.

This stock has not been surveyed. Fishing mortality on mature males in 1989, based on analysis of fishery CPUE, was above F_{MSY}. A stock survey is planned for 1991 to determine if this analysis is an artifact of limited distribution of effort, seasonal recruitment, or other factors not reflecting true changes in abundance. If additional information is not available, commercial fishing will be curtailed in 1991-92.

Dutch Harbor stock--The 1990 catch from the Dutch Harbor brown king crab stock decreased 7% since 1989 (840 to 780 t). Effort by 16 vessels making 68 landings during the 1 September-9 November season increased 26% over 1989 (43,345 to 54,618 pot lifts). Catch per unit effort declined 30% from 10 to 7 legal crabs per pot lift.

This stock has not been surveyed. Fishing mortality on mature males in 1990, based on analysis of fishery CPUE, was above F_{MSY}. A stock survey is planned for 1991 to determine if this analysis is an artifact of limited distribution of effort, seasonal recruitment, or other factors not reflecting true changes in abundance. If additional information is not available, commercial fishing will be curtailed in 1991-92.

Pribilof Islands and Northern Bering Sea stocks -- Fisheries in these districts have been sporadic during the last 10 years. One vessel fished for brown king crab in the Pribilof Islands area during 1990 but no catch was made. No effort was expended in the Northem Bering Sea in 1990. No population estimates are available for these stocks, and while no estimates of fishing mortality are available due to limited fishery data, fishing mortality is probably below F_{MSY}.

For further information

Alaska Department of Fish and Game. 1991. Westward region shellfish report to the Alaska Board of Fisheries, March 1991, 263 p. Div. Comm. Fish., RIR 4K91-4, Kodiak, AK 99615.

Stevens, B. G., and R. A. MacIntosh. 1990. Report to industry on the 1990 eastern Bering Sea crab survey. NWAFC Processed Rep. 90-09, 50 p., Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, P.O. Box 1638, Kodiak, AK 99615.

23. TANNER AND SNOW CRABS

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.

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 carapace width (4.3 in) and 90 mm (3.5 in) 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 increased 231% in 1990 (3,397 to 11,235 t), and value increased 115% ($21.3 to $45.7 million).

Bering Sea stock -- The 1990 catch of Bering Sea Tanner crabs increased 250% over 1989 levels (3,181 t to 11,135 t), continuing an increasing trend which began in 1988. Effort by 179 vessels making 1,032 landings during the 15 January-24 April season increased 285% over 1989 levels (184,892 to 711,137 pot lifts). Catch per unit effort decreased 6% (16 to 15 legal crabs per pot lift).

The 1990 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 carapace width and females greater than 84 mm carapace width, corresponding approximately to the mature stock, was 230 million crabs in 1990 compared to 208 million in 1989, an increase of 11%. The mature stock has been increasing since 1985. The stock of legal males increased 29% from 42 million in 1989 to 54 million in 1990. Prerecruit male abundance in 1990 was down 23% from 1989 levels (102 to 79 million), indicating that the increase in the legal stock may slow in the near future. The abundance of mature males has likewise declined 8% (144 million in 1989 to 133 million in 1990). Fishing mortality on the mature stock in 1990 was below F_{MSY}.

Eastern Aleutians stock -- The catch of Tanner crab from the Eastern Aleutians stock in 1990 decreased 47% below 1989 levels (148 to 78 t). Effort by 10 vessels making 75 landings during the 15 January-9 April season decreased 53% from 1989 (14,685 to 6,858 pot lifts). Catch per unit effort increased 10% from 10 to 11 legal crabs per pot lift.

A survey of this stock by ADF&G during summer 1990 indicated a very small C. bairdi population. Fishing mortality in 1990, based on analysis of fishery CPUE, was below F_{MSY}.

Western Aleutians stock -- Tanner crab landings from the Western Aleutians stock in 1989 decreased 68% below 1988 levels (68 to 22 t). Effort by 12 vessels making 30 landings during the 1 November-9 April season decreased 67% from 1988 (18,906 to

6,204 pot lifts). Catch per unit effort remained the same at 4 legal crabs per pot lift. 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.

Snow Crab

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. Males of C. opilio may attain a carapace width in excess of 152 mm (6 in). In U.S. waters a market minimum size of about 102 mm (4 in) carapace width is in effect, and individuals in the catch commonly average 0.5-0.7 kg (1 to 1.5 lb). Male and female size at 50% maturity is considered to be 65 mm (2.6 in) carapace width 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 increased 8% in 1990 (67,793 to 73,366 t), and value decreased 8% ($112.1 to $103.5 million). Effort by 178 vessels making 1,566 landings during the 15 January-12 June season increased 45% over 1989 (663,442 to 962,394 pot

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

YEAR	Bering Sea	Eastern Aleutians	Western Aleutians	TOTAL
1981	13,486	297	100	13,883
1982	4,994	336	380	5,710
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	11,135	78	22	11,235

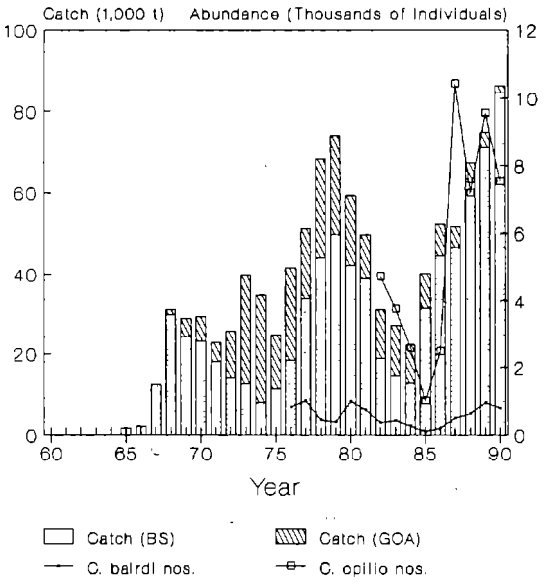
TANNER CRAB (Chionoecetes bairdi)
Bering Sea/Aleutians Region

	Bering Sea	Eastern Aleutian	Western Aleutian
Long-term potential catch (t)	12,247	318	91
Importance of non-commercial fishery	Minor	Minor	Minor
Management	State/ Fed.FMP	State/ Fed.FMP	State/ Fed.FMP
Status of exploitation	Fully-exploited[1]	Fully-exploited	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 level	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(90)	0.08	0.19	Unknown

[1] Fully-exploited status includes socioeconomic factors.

lifts). Catch per unit effort decreased 24% (178 to 135 legal crabs per pot lift). The 1990 NMFS summer survey indicated that abundance of males greater than 79 mm carapace width and females greater than 49 mm carapace width, corresponding approximately to the mature stock, was 4,184 million crabs in 1990 compared to 4,677 million in 1989, a decrease of 11%. However, the mature stock remains high. Abundance of large males increased from 187 million in 1989 to 420 million in 1990 (125%). Prerecruit male (80-104 mm carapace width) abundance in 1990 was up 44% from 1989 (746 million to 1077 million). The abundance of mature males increased 56% (886 million to 1,387 million). Fishing mortality on the mature stock in 1990 was below F_{MSY}.

Tanner Crab; Chionoecetes
Bering Sea and Gulf of Alaska



SNOW CRAB (Chionoecetes opilio)
Bering Sea

Stock	= Bering Sea
Long-term potential catch	= 15,876 t
Importance of non-commercial fishery	= Minor
Management	= State/Fed.FMP
Status of exploitation	= Fully-exploited[1]
Age at 50% maturity (males & females)	= 4
Size at 50% maturity males	= 78
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(90)	= 0.07

[1] Fully-exploited status includes socioeconomic factors.

SNOW CRAB
(Chionoecetes opilio)
Bering Sea
Commercial Landings (t)

	Bering Sea Stock
1981	23,927
1982	13,316
1983	11,852
1984	12,162
1985	29,937
1986	44,445
1987	46,223
1988	60,809
1989	67,793
1990	73,366

For further information

Alaska Department of Fish and Game. 1991. Westward region shellfish report to the Alaska Board of Fisheries, March 1991, 263 p. Div. Comm. Fish., RIR 4K91-4, Kodiak, AK 99615.

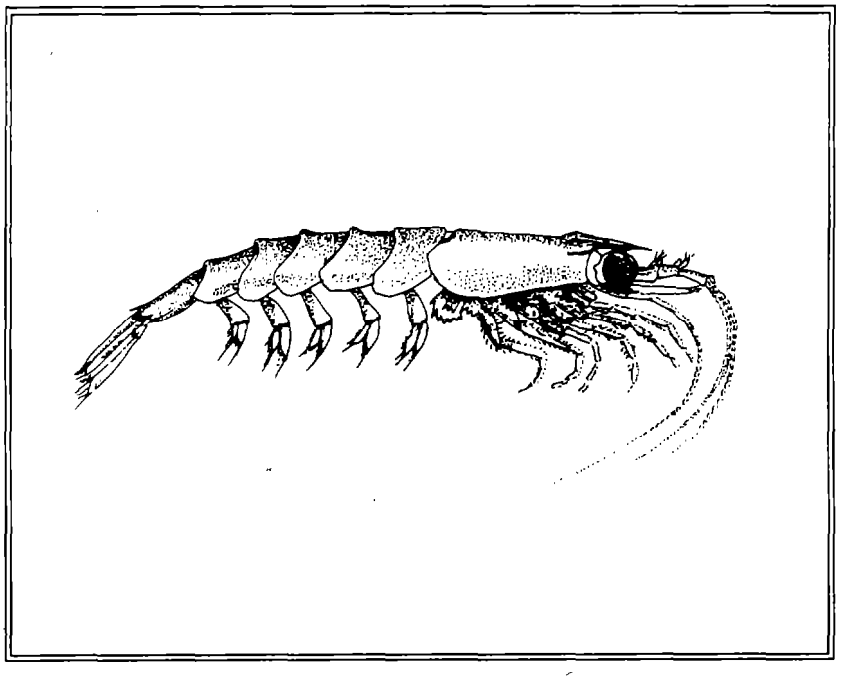
Stevens, B. G., and R. A. MacIntosh. 1990. Report to industry on the 1990 eastern Bering Sea crab survey. NWAFC Processed Rep. 90-09, 50p., Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, P.O. Box 1638, Kodiak, AK 99615.

24. SHRIMP AND SEA SNAILS

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 the Northern pink shrimp, Pandalus jordani) 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 stock.

From the 1960s, catches rose steadily to about 58,000 tin 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. Long-term potential yield 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 spacies range from 100 to 120 mm (3.9-4.7 in). 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 (2.3-3.0 in). 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. N. pribiloffensis, N. lyrata, and F. oregonensis make up the bulk of the snail biomass in the eastern Bering Sea.

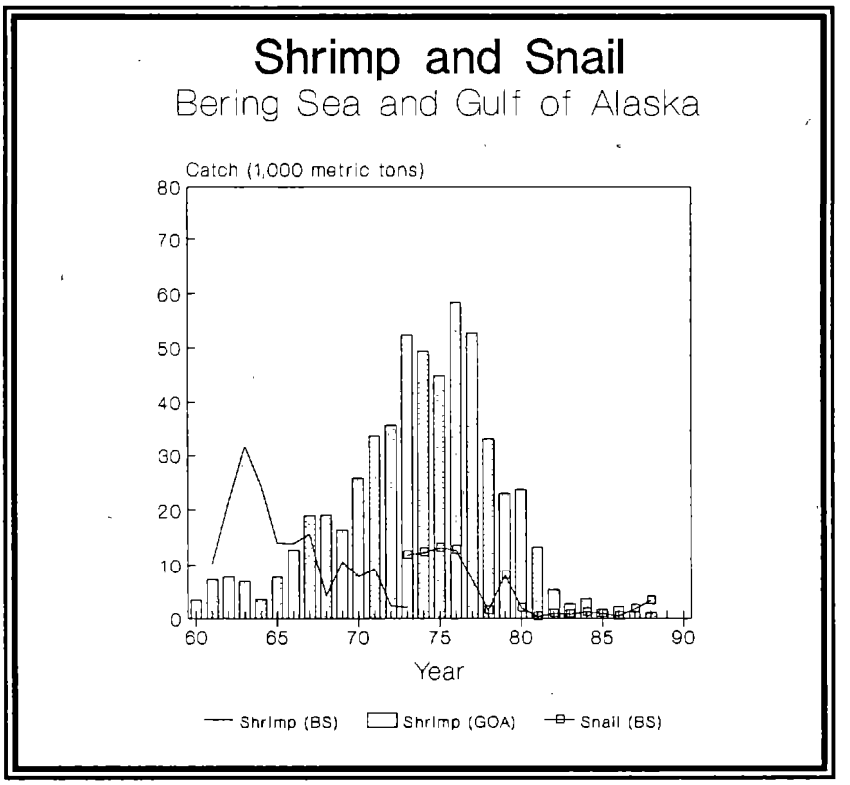
Life histories are similar among species. Sexes are separate and fertilization is internal. Among larger species, maturity occurs at 90-110 mm lengths (3.5-4.3 in), which probably corresponds to an age of about 10 years. Young are hatched from egg capsules, and almost all species have no larval stages. 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 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%.

SEA SNAILS
Bering Sea/Aleutians Region

Stock	= Bering Sea
Long-term potential catch	= 4,766 t
Importance of non-commercial fishery	= Minor
Management	= Fed.PMP
Status of exploitation	= Under-exploited
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 level	= None
Assessment Parameters	= Unknown



Probably less than 20 vessels participated in the fishery annually, ranging in size from 96 to 490 gross tons, 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.

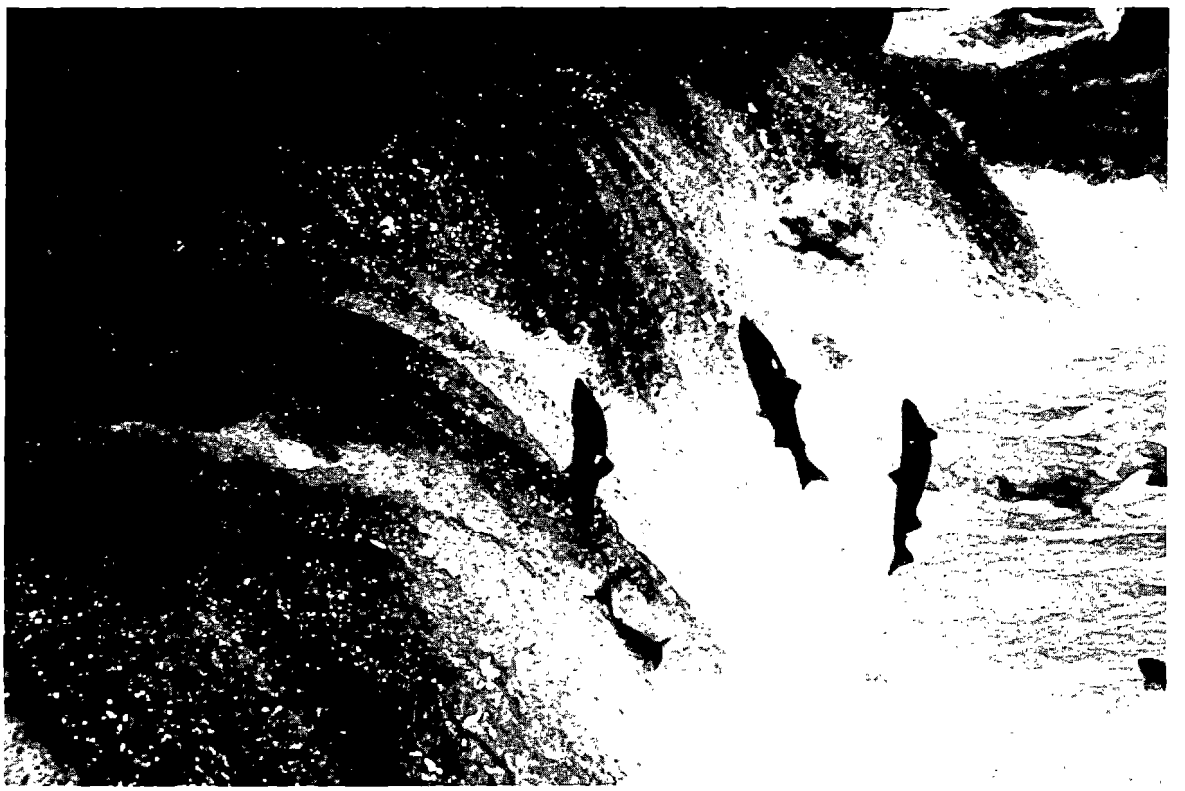
For further information

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

SEA SNAILS
Bering Sea/Aleutians
Commercial Landings (t)

YEAR	LANDINGS
1981	885
1982	841
1983	1,207
1984	852
1985	389
1986	1,826
1987	3,267
1988	0
1989	0
1990	0

PACIFIC SALMON RESOURCES



The Pacific salmon fisheries in Alaska contribute to the food supply and economy of the Nation and ranks as the largest nongovernmental 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

150 million salmon. Ex-vessel value of the 1990 catch was about $540 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 salmon 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 sac 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 salt water 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 salmon populations; and 3) at least one winter rearing in freshwater streams or lakes after emergence with migration to sea at age 1 or older, typical of coho, stream type (spring) chinook, and most sockeye salmon populations.

In the North Pacific Ocean, salmon from Alaska feed with other North American stocks and may migrate thousands of miles and mix with stocks from Asia. Some stocks will migrate into international waters outside of the 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 pounds for pink, 5-8 pounds for sockeye, 10-15 pounds for chum, 7-12 pounds for coho, and 17-50

pounds for chinook salmon. As Alaska stocks return to natal spawning areas, they mix with stocks from British Columbia and the Pacific Northwest along the Alaska coast.

Management of salmon in the vast Alaska region requires a complex mixture of domestic and international governing bodies, treaties, regulations, and agreements. Federal and State agencies participate with the NPFMC, the International North Pacific Fisheries Commission (INPFC), Pacific Salmon Commission (PSC), U.S. and Canada Yukon River salmon negotiations, high-seas drift net fisheries negotiations, and in meetings with Canada, Japan, and the U.S.S.R. to develop a Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean.

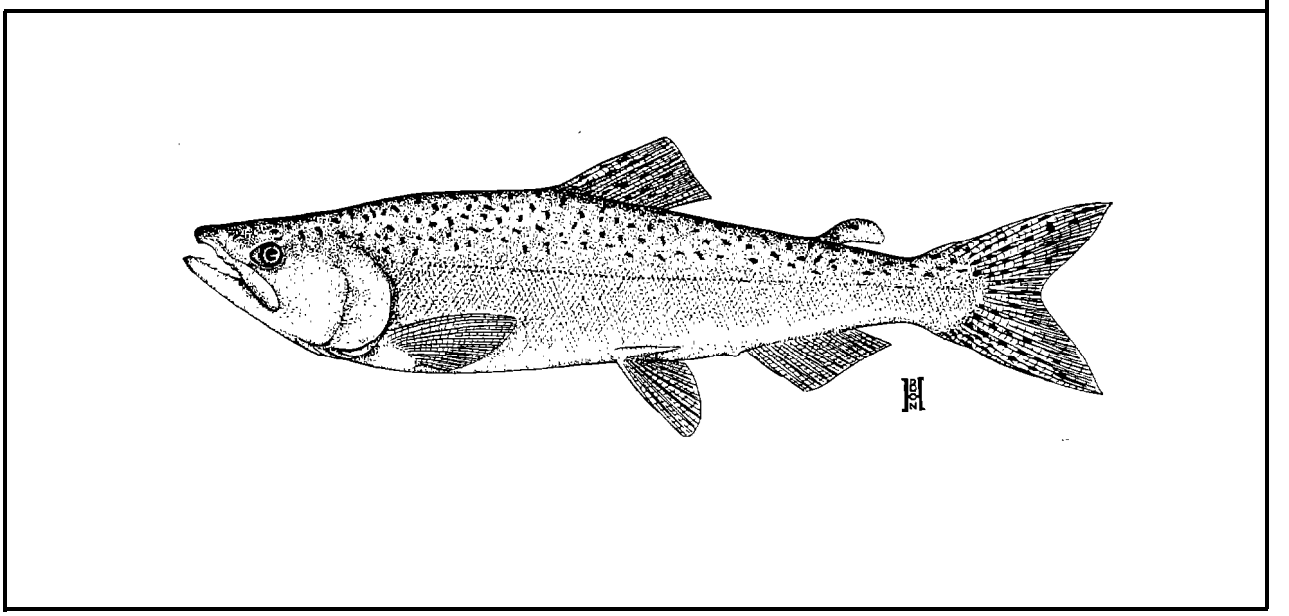
Salmon management in the EEZ is the responsibility of the NMFS and the NPFMC off the coast of Alaska from 3 to 200 miles offshore. In state waters, where most fisheries occur, fisheries are managed by the ADF&G on a district-by-district basis. Catches of Alaska Pacific salmon in high-seas fisheries outside the EEZ may be significant. The full impact of the high-seas fisheries cannot be easily evaluated until sufficient baseline data are obtained. Some progress is being made through cooperative research with Asian governments to increase our understanding of ocean migrations and stock mixtures of salmon in high-seas feeding areas. Negotiations between governments continue for the purpose of promoting the conservation of salmon stocks in the North Pacific Ocean.

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 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 resulting in rebuilding of depressed chinook salmon stocks in Southeast Alaska; chinook salmon 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. The stocks have generally rebuilt to or beyond previous high levels. On a regional basis, some stocks may be over-utilized. Rebuilding of some stocks, particularly chinook and coho salmon, may now be impacted by high-seas catches. Three prominent issues currently impacting optimum yields are interceptions in high-seas driftnet fisheries, bycatch of chinook salmon in the domestic groundfish fishery, and impacts of industrial activities on salmon spawning and rearing habitats.

The following chapters on Pacific salmon resources were written by James C. Olsen.

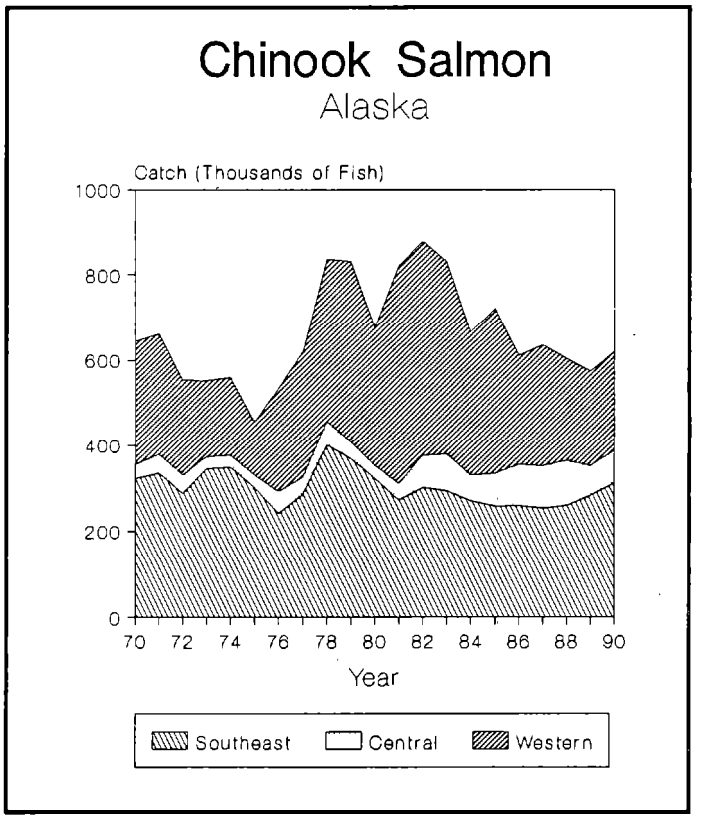
25. CHINOOK SALMON



The chinook or king salmon (Oncorhychus tshawytscha) is the. largest of the Pacific salmon with some adults weighing over 50 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.

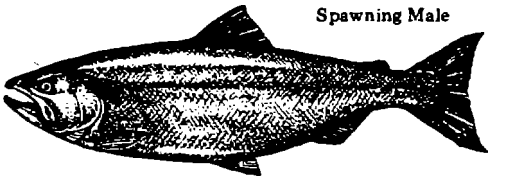
Alaskan rivers normally have a single run of spawning chinook salmon which lasts from May through July. Adults return to fresh water after 2 to 5 years at sea. Females deposit from 3,000 to 14,000 eggs which hatch in late winter or early spring. Most juvenile chinook salmon remain in fresh water until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

Most commercial catches are made by troll and gill-net fisheries in nearshore areas. Total statewide catch has averaged about 694,000 fish annually between 1980 and 1990. This catch includes about 60,000 adult chinook salmon produced by hatcheries in Southeast and Central Alaska. Sport fisheries annually take about 134,000 chinook salmon.



CHINOOK SALMON
Alaska
COMMERCIAL CATCH
(1,000's 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	622



Spawning Male

Chinook salmon migrate long distances in the North Pacific Ocean. Salmon caught in the southeast (east of long. 144°W) and central (west of long. 144°W, south of Alaska Peninsula) 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 are now managed under the U.S.-Canada Pacific Salmon Treaty. Chinook salmon harvests have been relatively stable since the late 1980s. Many wild stocks are now increasing in abundance under catch restrictions imposed by the Treaty.

All stocks in Alaska are fully utilized and many stocks are responding to management and enhancement efforts. Recent decreases in harvests in the Westem Region (area north of the Alaska Peninsula) reflect weaker returns to Bristol Bay and the Lower Yukon River areas. In Bristol Bay, the 1990 return was below average for the fourth consecutive year.

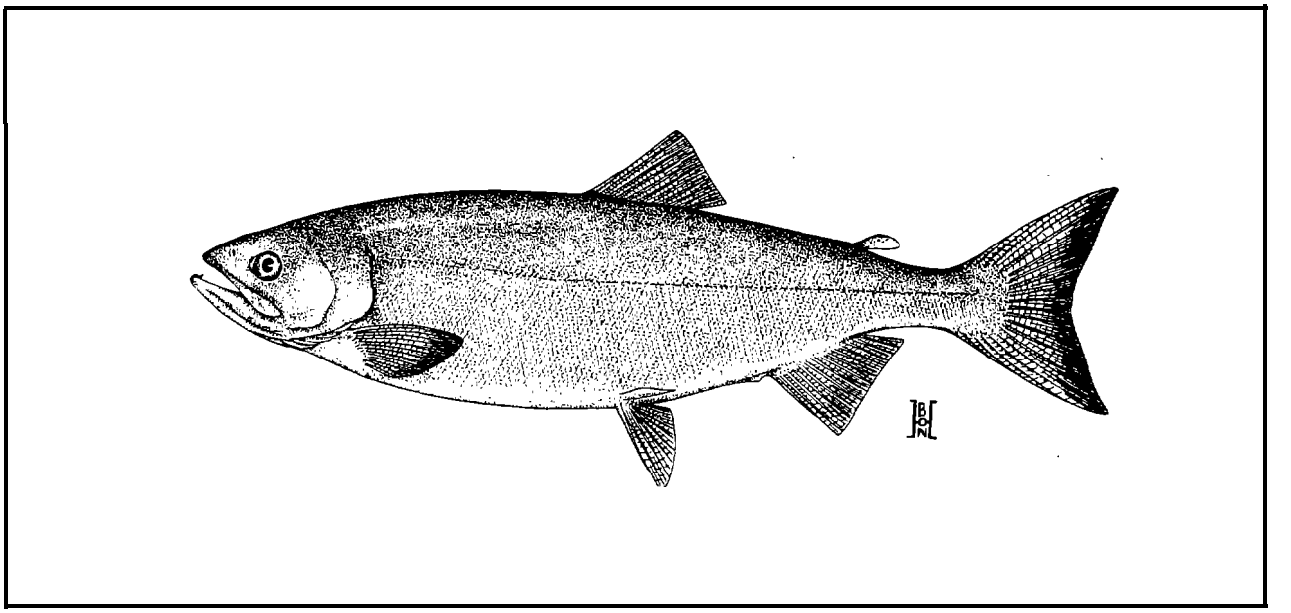
Some stocks may be hurt by foreign high-seas catches. High-seas catch data are incomplete and more research is needed to establish baseline data so that Pacific salmon of North American and Asian origin can be identified. Some chinook salmon are taken incidentally by U.S. groundfish trawlers in the Bering Sea and the Gulf of Alaska. The NPFMC continues to work with the U.S. fishing industry to reduce chinook salmon bycatches.

CHINOOK SALMON
Alaska

Average catch (1980-90):	Alaska	= 5,814 t
	Southeast region	= 2,005 t
	Central region	= 813 t
	Western region	= 2,996 t
Average catch (1988-90):	Alaska	= 4,711 t
	Southeast region	= 2,017 t
	Central region	= 845 t
	Western region	= 1,849 t
Long-term potential yield (MSY):		
	Alaska	= 5,814 t
	Southeast region	= 2,005 t
	Central region	= 813 t
	Western region	= 2,996 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, 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.

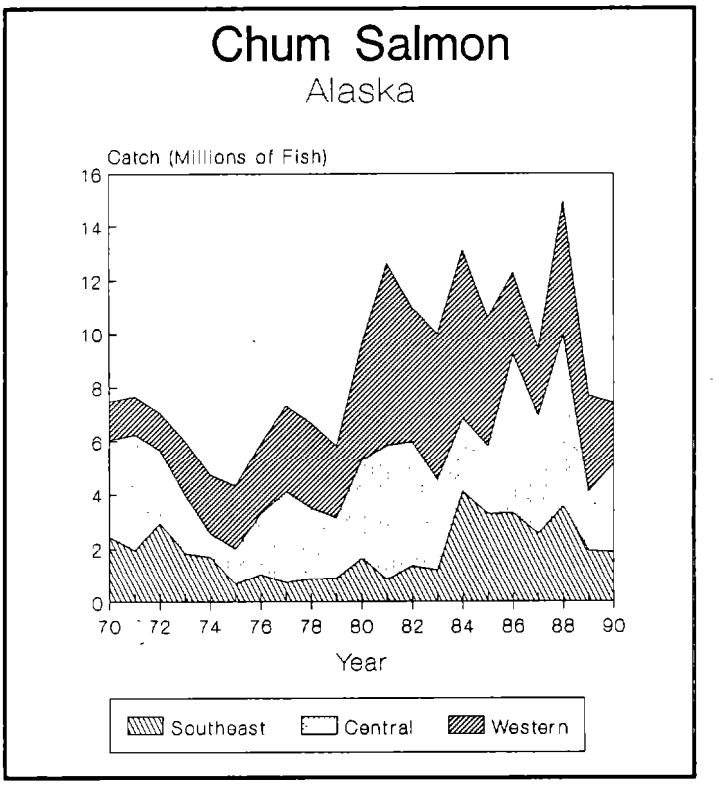
26. CHUM SALMON



Chum salmon (Oncorhynchus keta) has 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.

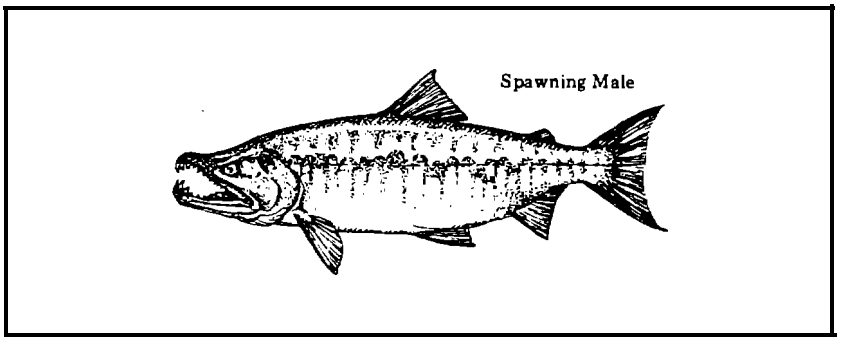
Chum salmon often spawn in large rivers and stream areas where upwelling ground water is present. In some areas, they can be found spawning in the same places as pink salmon, including the intertidal reaches of rivers. Some chum salmon travel long distances in rivers before spawning. In the Yukon River, 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 move downstream and by fall have entered the ocean. They remain in the Ocean from 2 to 4 years. Chum salmon vary in size at maturity and average about 3-8 kg (7 -18 lb). Some may weigh as much as 20 kg.



CHUM SALMON
Alaska
COMMERCIAL CATCH
(1,000's 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	7,417



Most chum salmon are caught in gill nets and purse seines. 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. By 1990, 21% of the catch in the southeast and central regions was from hatcheries.

On a statewide basis, chum salmon populations are fully utilized. 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 pink salmon.

Stocks in the western region may be impacted by the foreign high-seas driftnet fisheries for salmon and squid. Large numbers of chum salmon are caught, but country-of-origin data are sparse. More research is needed to establish baseline data so that Pacific salmon of North American and Asian origin can be identified.

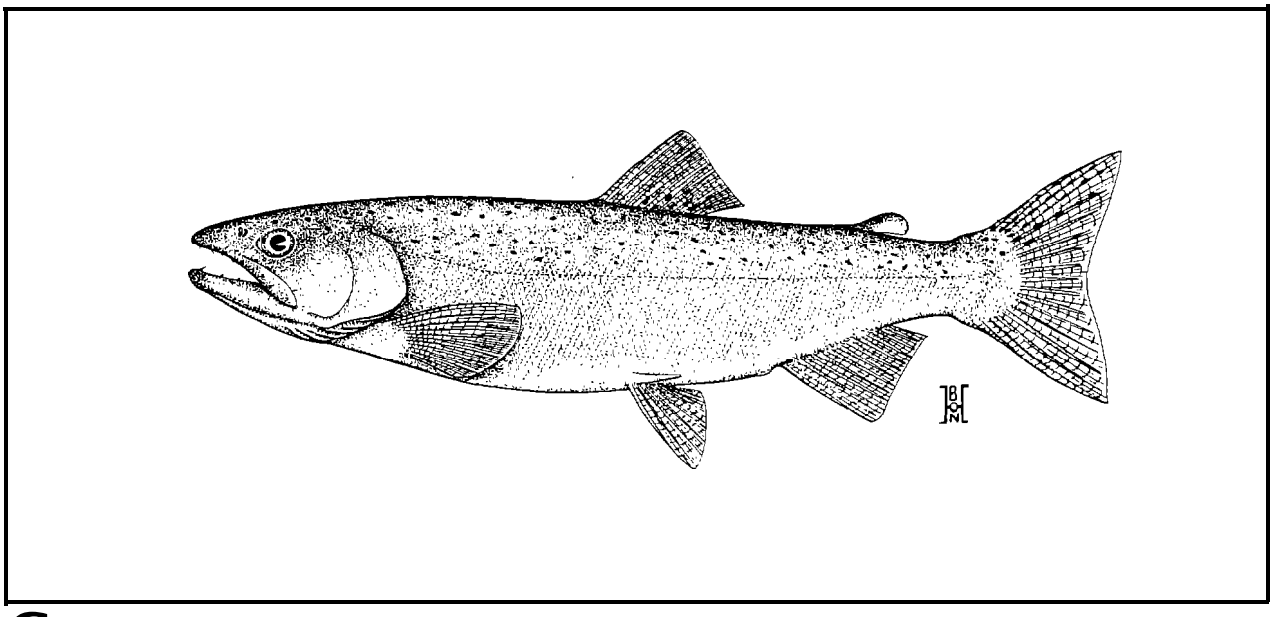
Concerns for the conservation of some stocks in the southern southeast region have been raised where lower than average returns to spawning areas are observed. Reasons for the declines are not fully understood but may be due to changes in ocean survival, overharvesting of stocks by coastal fisheries, and degradation in freshwater habitats.

CHUM SALMON
Alaska

Average catch (1980-90):	Alaska	= 38,900 t
	Southeast region	= 10,056 t
	Central region	= 14,646 t
	Western region	= 14,198 t
Average catch (1988-90):	Alaska	= 36,547 t
	Southeast region	= 10,605 t
	Central region	= 14,433 t
	Western region	= 11,509 t
Long-term potential yield (MSY):		
	Alaska	= 38,900 t
	Southeast region	= 10,056 t
	Central region	= 14,646 t
	Western region	= 14,198 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

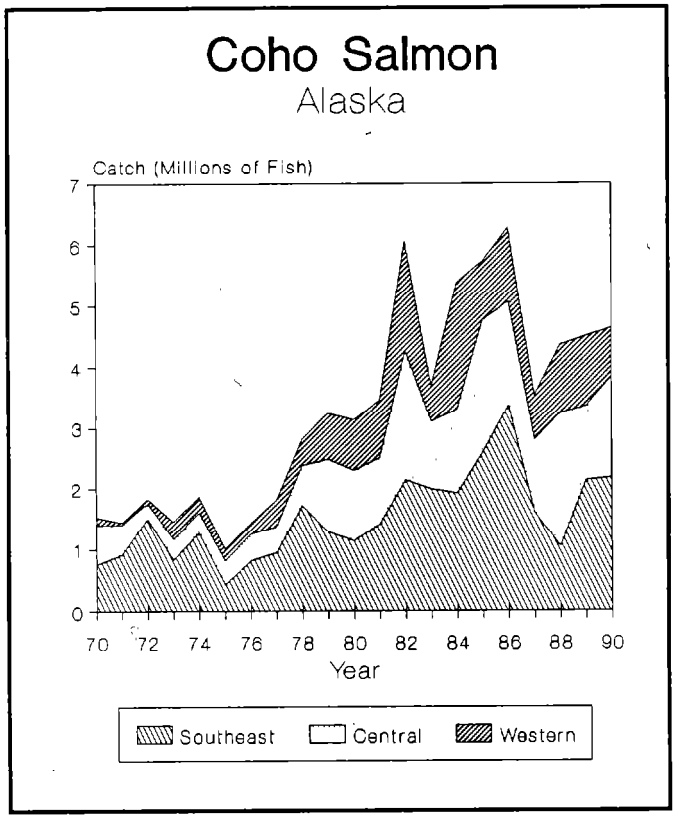
Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

27. COHO SALMON



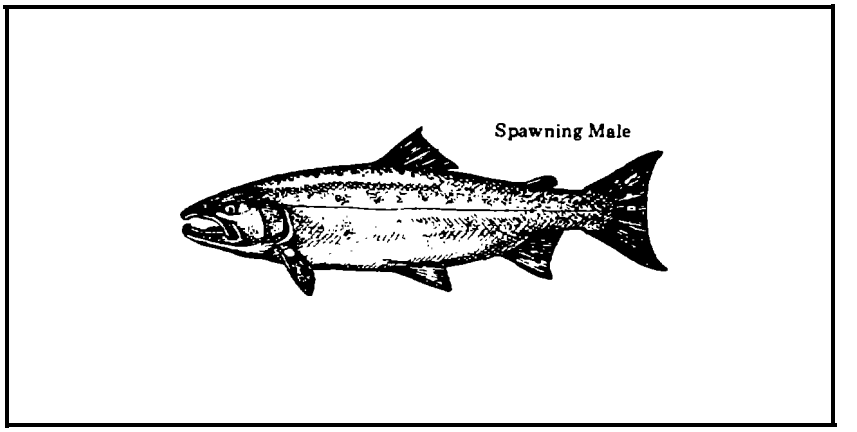
Coho salmon (Oncorhynchus kisutch) are found throughout Alaska. It is the third largest species of Pacific salmon. Maturing coho salmon enter fresh water from August through November. Spawning takes place in Alaska from late September through January when females deposit from 2,400 to 4,500 eggs. The juveniles spend one, two, or three winters in fresh water then migrate to the ocean where they spend one winter and return to their freshwater stream of origin.

Troll and net fisheries for coho salmon in Alaska now land about 4.6 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 6.2 million fish. About 5% of the catch is currently from



COHO SALMON
Alaska
COMMERCIAL CATCH
(1,000's 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	4,634



the EEZ troll fisheries. Coho salmon from hatcheries and lake stockings made up about 17% of the catch in 1990 in the southeast and central regions. Since 1986, enhancement has produced 8-17% of the catches in the two regions.

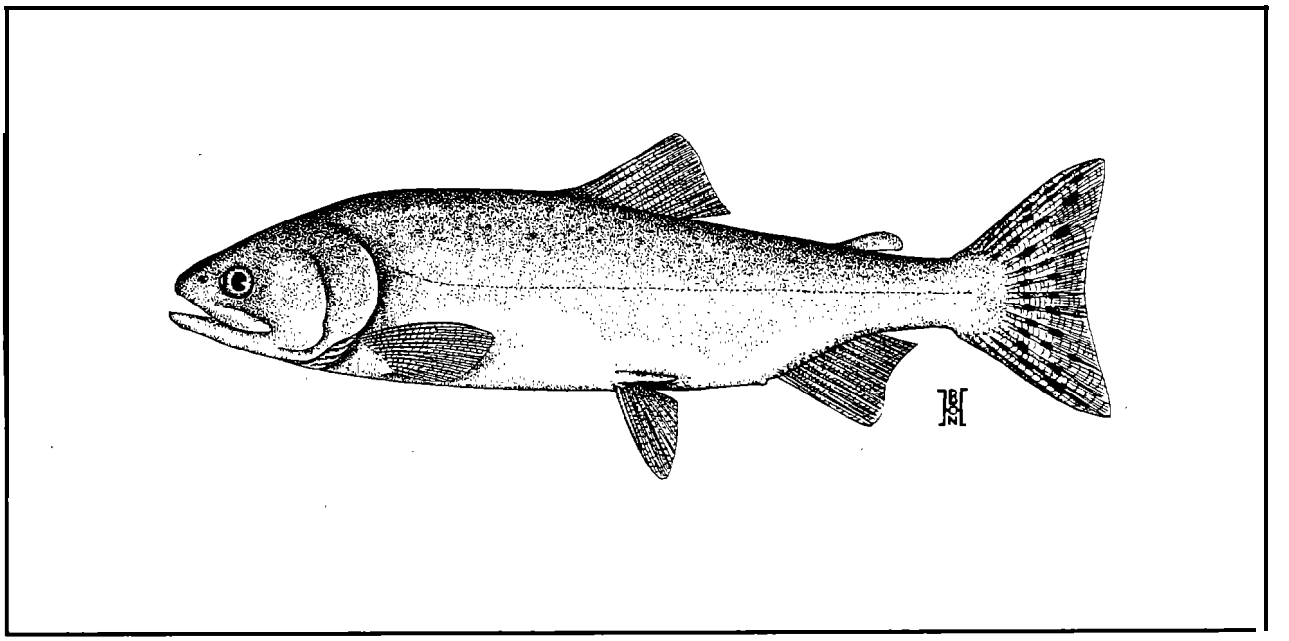
The status of coho salmon stocks in the state is apparently good judged by recent catch levels. All stocks are fully utilized. In most management areas, stocks yield good catches and returns to spawning areas. There is concern that some stocks may be hurt by foreign high-seas driftnet fishing for Pacific salmon and for squid. High-seas catch data are incomplete. More research is needed to establish baseline data so salmon of North American and Asian origin can be identified. Other activities may impact 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 Southeast Alaska., logging in the Tongass National Forest and on State and native lands has impacted who salmon habitat. Greater protection for 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 (1980-90):	Alaska	= 15,372 t
	Southeast region	= 6,170 t
	Central region	= 5,518 t
	Western region	= 3,684 t
Average catch (1988-90):	Alaska	= 14,162 t
	Southeast region	= 5,139 t
	Central region	= 5,616 t
	Western region	= 3,407 t
Long-term potential yield (MSY):		
	Alaska	= 15,372 t
	Southeast region	= 6,170 t
	Central region	= 5,518 t
	Western region	= 3,684 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

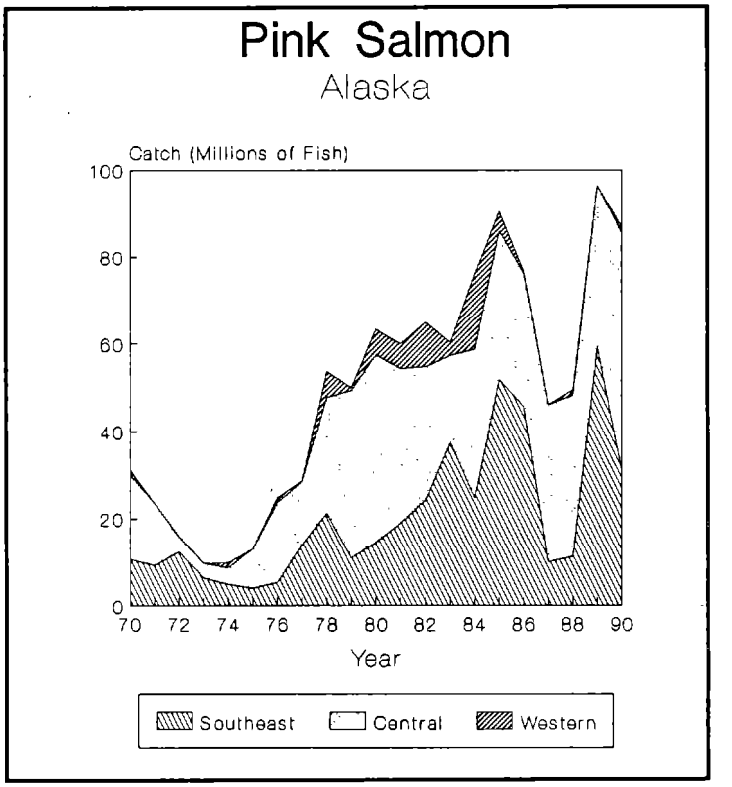
Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

28. PINK SALMON



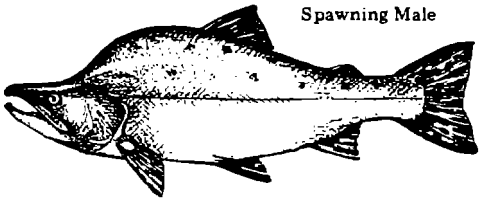
The pink salmon (Oncorhynchus gorbuscha) is often the staple fish in many coastal communities because of its abundance in much of Alaska. Commercially important runs of pink salmon occur in the southeast and central regions; Bristol Bay, in the western region, is the northern limit of large runs Pink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

The pink salmon is the smallest of the Pacific salmon in Alaska. Adult salmon return to spawn after 1 year 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. Some spawn in odd-numbered years and others spawn in even-numbered years. Frequently, in a particular stream, one cycle will dominate over the other. In other streams, each cycle may have sim-



PINK SALMON
Alaska
COMMERCIAL CATCH
(1,000's 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	86,839


Spawning Male

ilar abundance. Soon after emergence, the young fry migrate to the ocean, Pink salmon mature in 2 years.

PINK SALMON
Alaska

Average catch (1980-90):	Alaska	= 109,972 t
	Southeast region	= 45,774 t
	Central region	= 57,145 t
	Western region	= 7,053 t
Average catch (1988-90):	Alaska	= 118,232 t
	Southeast region	= 51,450 t
	Central region	= 65,531 t
	Western region	= 1,251 t
Long-term potential yield (MSY):		
	Alaska	= 109,972 t
	Southeast region	= 45,774 t
	Central region	= 57,145 t
	Western region	= 7,053 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

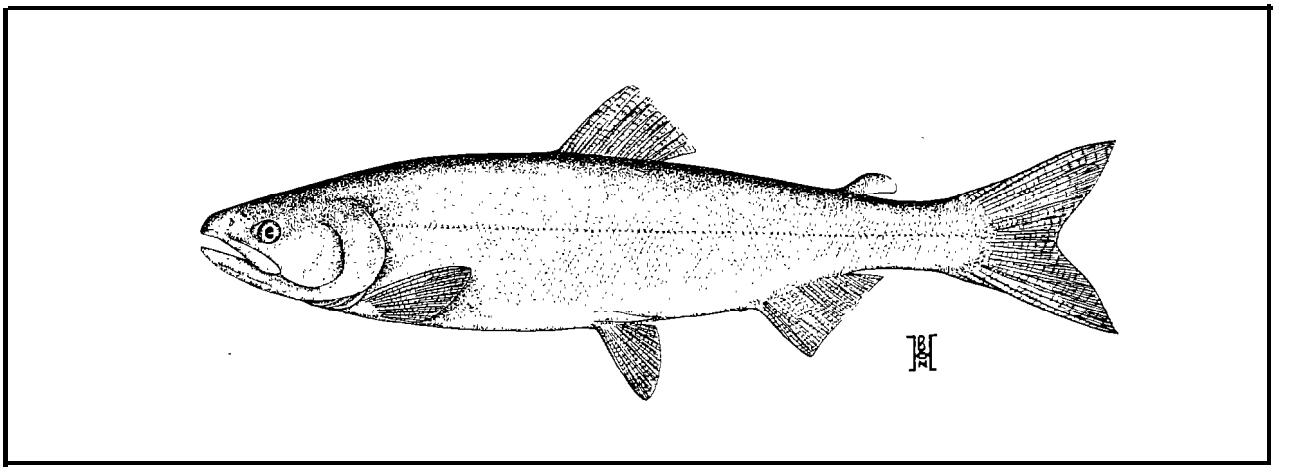
Southeast region = east of long. 144° W.
Central region = Prince William Sound, Cook Inlet, Kodiak, and south of Alaska Peninsula.
Western region = north of Alaska Peninsula.

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 1989 at a record 99 million fish.

Hatchery production in Southeast and Central Alaska now contributes significantly to the total catch. In the 1987-90 period, hatchery-produced pink salmon provided an average of 30% of the total statewide catch. About 90% of the hatchery-produced catch originated in Prince William Sound.

On a statewide basis, pink salmon populations are fully utilized. Most stocks appear to have been rebuilt to or beyond previous high levels as judged by catch data. Recent annual yields in the western region have been significantly decreased in the Bristol Bay area where catches and returns are below average.

29. SOCKEYE SALMON



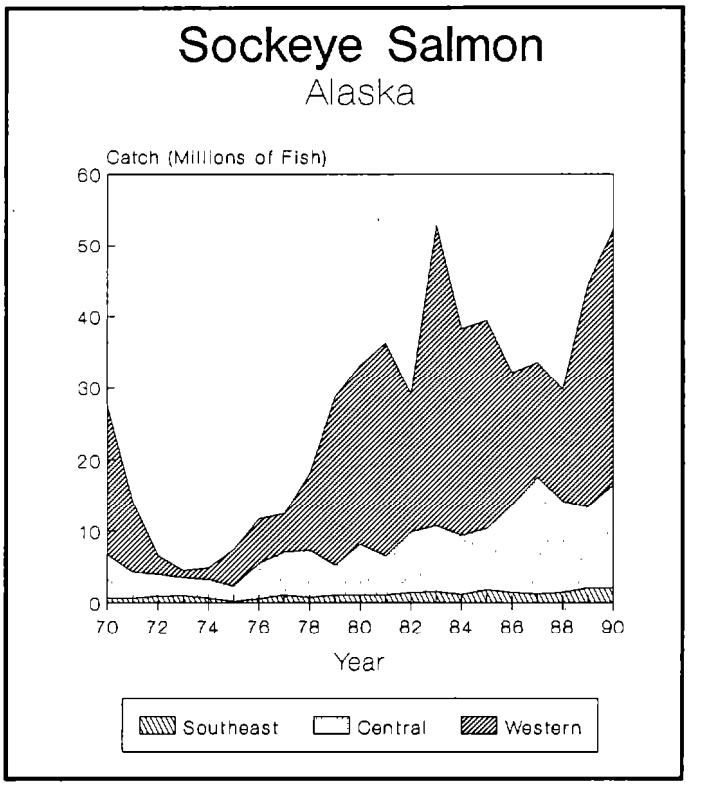
The sockeye or red salmon (Oncorhynchus nerka) is Alaska's most valuable salmon. It occurs throughout much of Alaska and supports commercial fisheries in Bristol Bay and Central and Southeast Alaska.

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 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 U.S.-Canada Pacific Salmon Treaty. Sockeye salmon from British Columbia occur in varying numbers each year in Southeast Alaska waters where they 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 64% of the total catch has come from Bristol Bay.

Sockeye salmon catches were low in the mid-1970s, but subsequently increased and reached an all-time record of 52.7 million fish in 1983 as stocks were rebuilt. Recent average catch, 1988-90, was 42.2 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 18% of the catch in 1990. From 1987 to 1990, the average contribution from enhancement to commercial catches was 11%. 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 lo-year averages. Record catches in 1990 were recorded in Bristol Bay and off Kodiak Island while many other areas had above-average catches. One area with lower than average returns of wild stocks was Prince William Sound.

SOCKEYE SALMON
Alaska
COMMERCIAL CATCH
(1,000's 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	52,228

SOCKEYE SALMON
Alaska

Average catch (1980-90):	Alaska	=	103,661 t
	Southeast region	=	4,350 t
	Central region	=	28,984 t
	Western region	=	70,327 t
Average catch (1988-90):	Alaska	=	114,481 t
	Southeast region	=	5,347 t
	Central region	=	35,965 t
	Western region	=	73,169 t
Long-term potential yield (MSY):			
	Alaska	=	103,661 t
	Southeast region	=	4,350 t
	Central region	=	28,984 t
	Western region	=	70,327 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.

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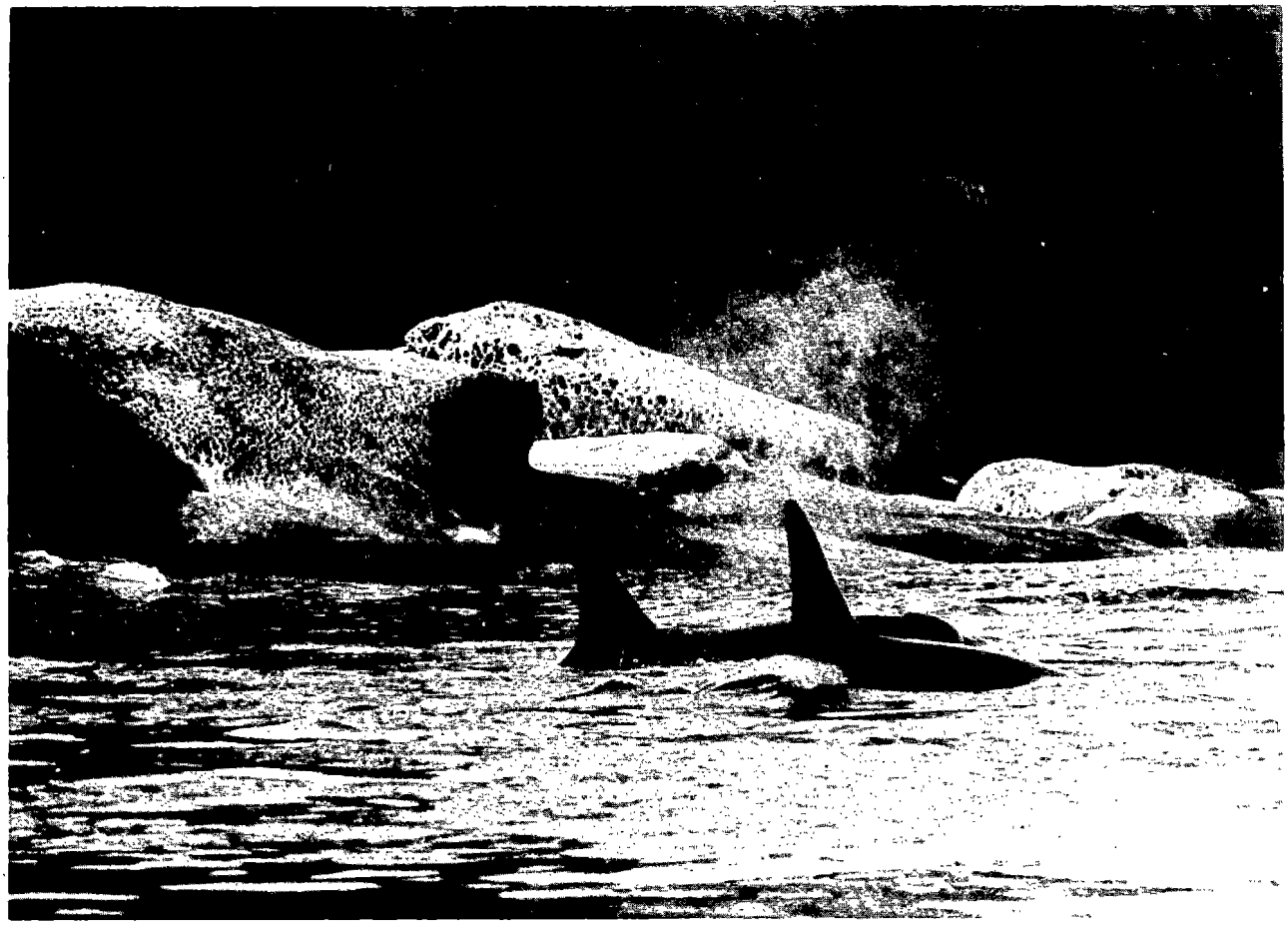
MARINE MAMMALS



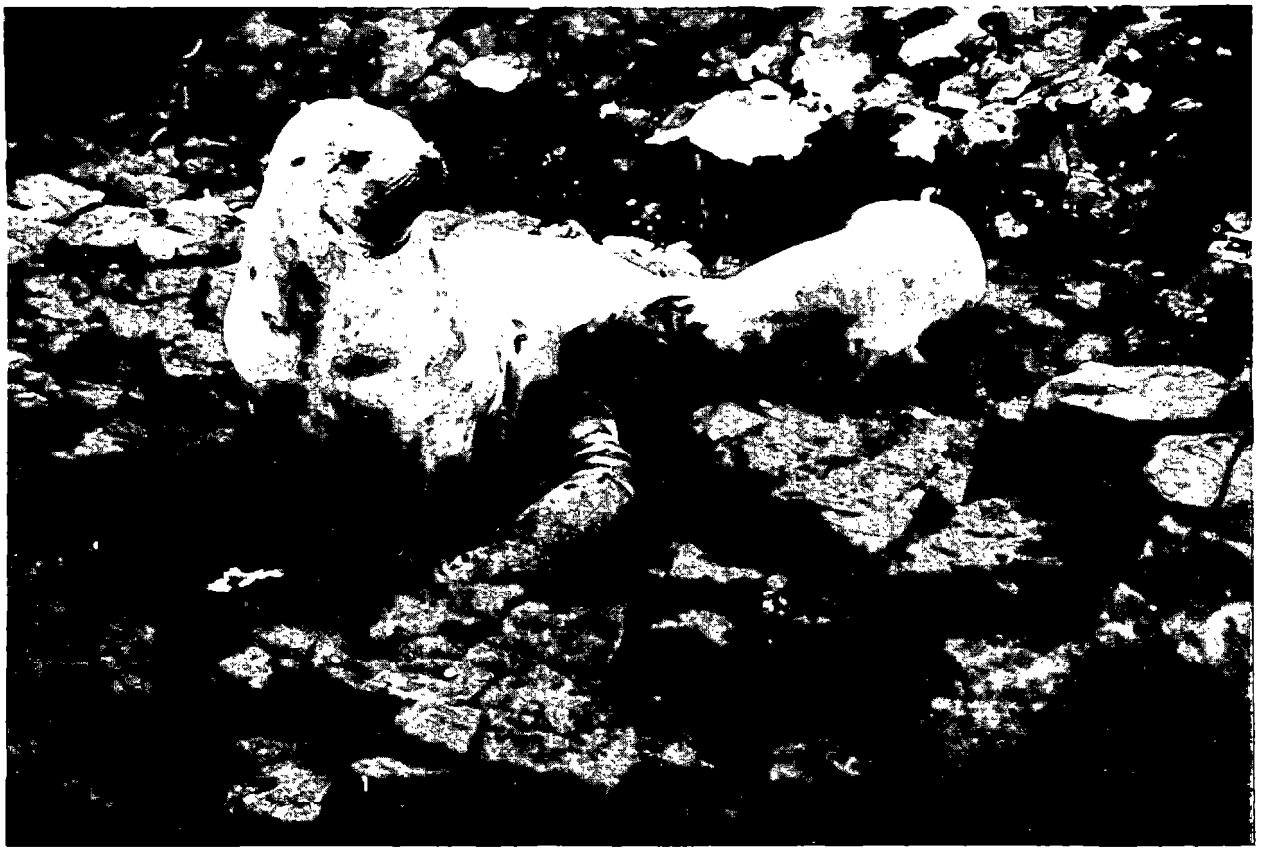
Forty-two species of marine mammals in U.S. waters of the North Pacific Ocean are under the jurisdiction of the Department of Commerce. This includes 31 species of whales, dolphins and porpoises, and 11 species of seals and sea lions. Six species are only found in Alaska; one species, the Hawaiian monk seal, is unique to Hawaii.

Fourteen of the most commonly observed species of marine mammals are normally found close to shore, such as the California gray whale and California sea lion. 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 especially by whales and dolphins, are for traveling 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, such as humpback whales and northern fur seals, whereas others are found year-round from Alaska to California, such as harbor porpoise and Pacific harbor seals. These zoogeographic differences have led to unique 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

INCIDENTAL TAKE OF SELECTED MARINE MAMMALS IN DOMESTIC FISHERIES OFF ALASKA

Species	Incidental Take (95%CI) (CV)	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 (1988-90)	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



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	21,113 (19,737-22,489)	+3.2%/yr (1968-88)	Land-based counts	Complete	Recovered ESA (e)
Humpback whales	1,398-2,040	Unknown	Photographic mark-recap.	Complete?	Below OSP ESA (e)
Killer whale	Unknown	Unknown	Individual counts	Partial	Uncertain MMPA
Beluga	15,800-18,450	Unknown	Aerial and land-counts	Complete?	Uncertain MMPA
Dall's porpoise	Uncertain	Unknown	Line transect	Partial	Uncertain MMPA
Harbor porpoise	Unknown	Unknown	--	--	Uncertain MMPA
Northern sea lion	>39,396	-70% (1970-90)	Counts on shore	Complete	Below OSP ESA (t)
Northern fur seal	871,000	-50% (1975-90)	Land-counts Pribilof Is.	Complete	Below OSP MMPA (d)
Harbor seal	Uncertain (<150,000)	-60% (1976-88)	Land-counts Tugidak Is.	Partial	Below OSP MMPA
Spotted[2] seal	Uncertain (>200,000?)	Unknown	Ice-counts	Partial	Uncertain

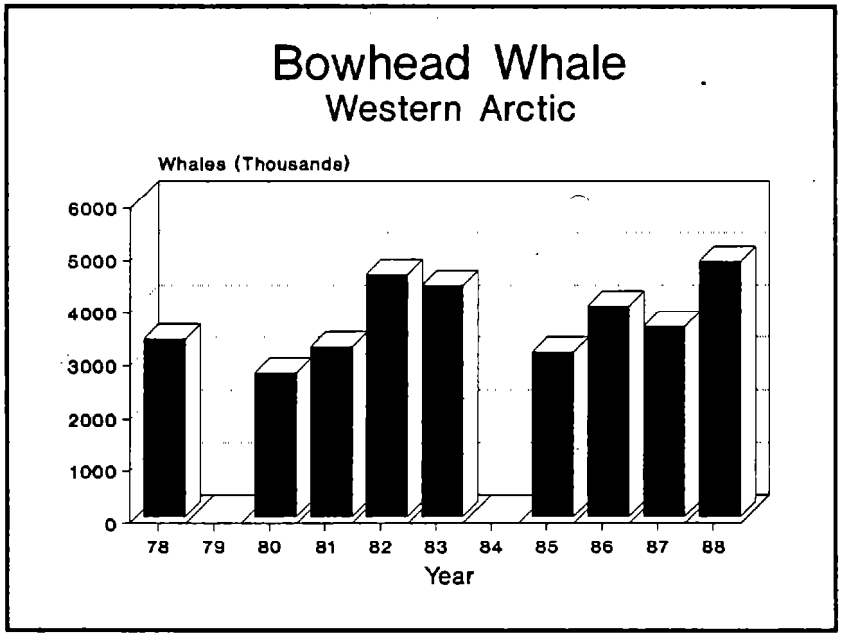
[1] Bowhead, gray and humpback whale estimates are for the entire eastern North Pacific Ocean; all others are for Alaska.
[2] Other ice-associated seals are the bearded, ribbon, and ringed seals.

(MMPA) of 1972 and the Endangered Species Act (ESA) of 1973. Both Acts require that management of marine mammals be based on the identification and enumeration of populations or stocks.

The following chapters on marine mammal resources in Alaska were compiled by Howard W. Braham.

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 Strait, and Hudson Bay-Foxe Basin) and two stocks in the North Pacific Ocean (Okhotsk Sea and western North American Arctic Ocean). Bowheads migrate off the western arctic Alaska coast from late March through June, traveling from the western Bering Sea (U.S.S.R.) into the Beaufort Sea (United States and Canada). Some remain in the Chukchi Sea during summer. The autumn migration back to the Chukchi Sea and eventually the Bering Sea occurs from September to December and precedes the advance of the pack ice. Critical habitat may include the spring open lead system from the northern Bering Sea 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 over-winter.

Calves are born from March to July following a 13-month gestation. Pregnancy rates vary from 0.16 to 0.33 and the calving interval is about 4-6 years. Length is approximately 4-6 m at birth, 8-9 m at age 1, and 13-14 m at sexual maturity. 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 Ocean, 18,660 bowheads were killed by Yankee whalers between 1848 and 1914. During this period, the total pop ulation abundance was probably less than 18,000-20,000. Over 60% of the take occurred between 1850 and 1870. Alaskan Eskimos (Inupiat and Yupik-speaking Inuit) have used bowhead whales for subsistence for several thousand years. This century the take of bowheads by all coastal Eskimo villages has averaged 20 whales 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 was instituted in 1978 by the International Whaling Commission and is jointly administered by the Alasken Eskimo Whaling Commission and the NMFS.

The present estimate of abundance of the western Arctic stock is 7,600 (95% C.I., 6,400-9,200) baaed on a combined analysis of ice-based observer counts and passive acoustics data collected off Point Barrow, Alaska, during. the bowheads' spring migration. Increases in abundance estimated since census studies began in 1978 reflect improvements in the methods of data collection and analysis and an actual increase in abundance. 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 when observations were not conducted due to bad weather or other reasons. Model simulations suggest that the stock has increased since 1920, just after commercial whaling ended. The present size of the stock is 40.9% (95% C.I., 3842) of its initial size (in 1848) based on simulation and sensitivity tests of historic data. These data suggest that the westem arctic stock of bowheads is recovering from commercial whaling and that the stock is below the population size supportable by the ecosystem (i.e., its carrying capacity) before 1850.

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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+

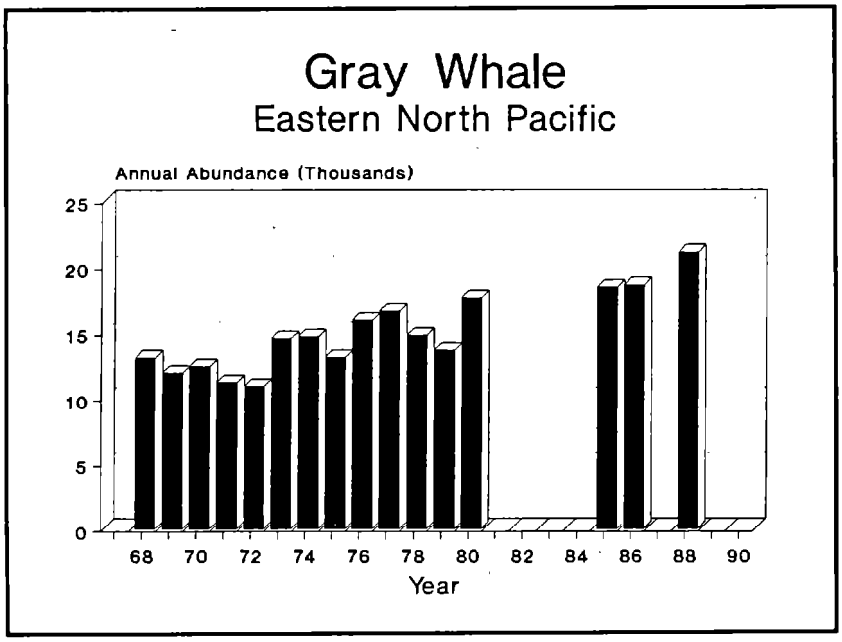
[1] An estimate of the fate of whales struck and lost is reported to NMFS by the Alaskan Eskimo Whaling Commission; a "+" means that the number killed, beyond the number landed, is unknown.

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., Canadian, and Soviet coasts) and the waters off Baja California. The second stock migrated from the Okhotsk Sea along the coasts of the Soviet Union, Japan, the People's Republic of China, and the Republic of Korea. The eastern North Pacific or "California" stock was heavily exploited, principally by Yankee whalers during the second half of the 19th century, and may have been reduced to only a small fraction of its preexploitation population size.

Gray whales in the eastern North Pacific Ocean, also called the "California" stock, are distributed across much of the southern Chukchi and northern Bering Seas where they feed from May to November. They migrate southward out of the Bering Sea by December. The southward migrating whales are found along the west coast of North America from November to February with the majority passing central Califorma from early December to early February. Some overlap occurs with the first of the northbound migrants leaving Baja California as the tail-end of the southbound migration arrives. A small number of whales do not undertake a full migration and spend the winter in waters south of Alaska.

As with other baleen whales, adult female gray whales reach sexual maturity at slightly greater lengths (12.95 m, SE. = 0.11) than do males (12.43m, SE. = 0.12), with maximum physical maturity reached at approximately 14 m in females and 13 m in males. Mean length is 4.6 m at birth (both sexes), 7-8 m at weaning (usually 6-8 months postpartum), and 8 m or greater at 1 year. Age at sexual maturity is 9 years (range 6-12) for females and 6 years (range 5-9) for males. The



mean date of conception is 5 December, the mean date of birth 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 once every 2 years, although S-year calving intervals are common. 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 21,113 (S.E. 688). This level is greater than or equal to the size of the population in 1846, estimated to have been 16,000-20,000. The population has been increasing at a rate of 3.2% per year (S.E. 0.6%) since 1968, which included a Soviet subsistence harvest of 167 whales per year (S.E. 3.5).

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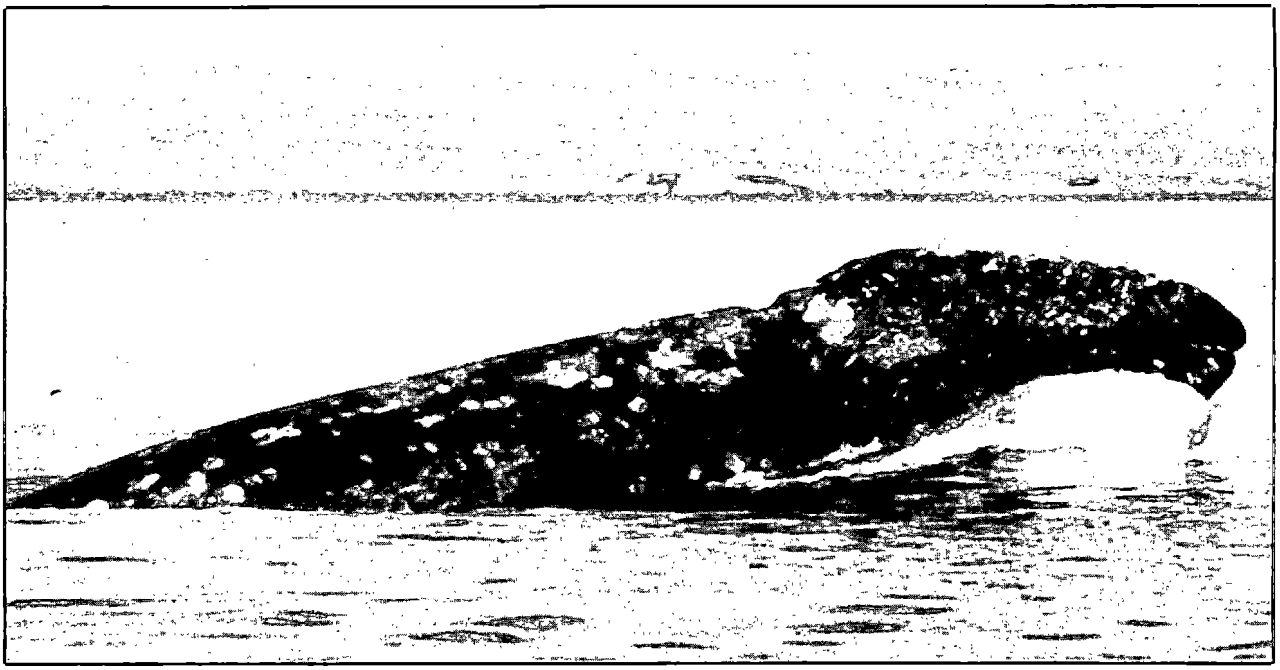

32. HUMPBACK WHALE

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 subtropical wintering grounds. The North Pacific humpback whale population tentatively has been divided into three stocks, based on the relative discreteness 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 off the coasts of California and Southeast Alaska, and in the Gulf of Alaska. The wintering grounds of humpbacks seen in the Bering and Chukchi Seas during summer months is unknown, although a small number of whales tagged in the westem North Pacific Ocean south of Japan in the 1950s and 1960s were recovered near the eastern Aleutian Islands a few years later.

Humpbacks inhabit Alaskan waters from late spring to early winter, approximately May to December. Peak abundance **of** whales off Southeast Alaska typically occurs in late August and September. Individual humpbacks may be seen in coastal areas of Alaska at any time of year, especially 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 for humpbacks off Southeast Alaska and in Prince William Sound, including fairly predictable local movements, such as those among favored feeding areas. Their distribution on the feeding grounds varies each year because of oceanographic conditions and the distribution and availability of prey.

The preexploitation population size (prior to 1906) 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 have been no surveys over a significant period of time to detect trends in abundance. It is not possible, therefore, to determine if the population is recovering under the current regime of international protection, which has been in force since the 1960s.

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 sug gest that 1,600-2,100 whales annually visited Hawaiian waters during the 1970s and 1980s. Reliable estimates are not available for the number of whales on the other wintering grounds off Mexico or in the western Pacific Ocean. 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 prior to commercial whaling.

An estimated 300 to 350 hump backs are present off Southeast Alaska during summer and autumn. Aerial and ship-based survey data have been used to estimate that about 400 humpbacks spend 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 presumed to be small. Less than 100 sightings of humpback whales have been made in the Bering Sea since 1976.

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 are reported entangled each year in gill nets and buoy lines off Southeast Alaska and British Columbia. In the summer **of** 1987, seven humpbacks were reported entangled in gill nets off Southeast Alaska; one whale died. No humpbacks have been reported taken in trawl fisheries monitored by NMFS observers. No estimates. are available on the incidental take of humpbacks in other commercial fisheries in other areas of Alaska.

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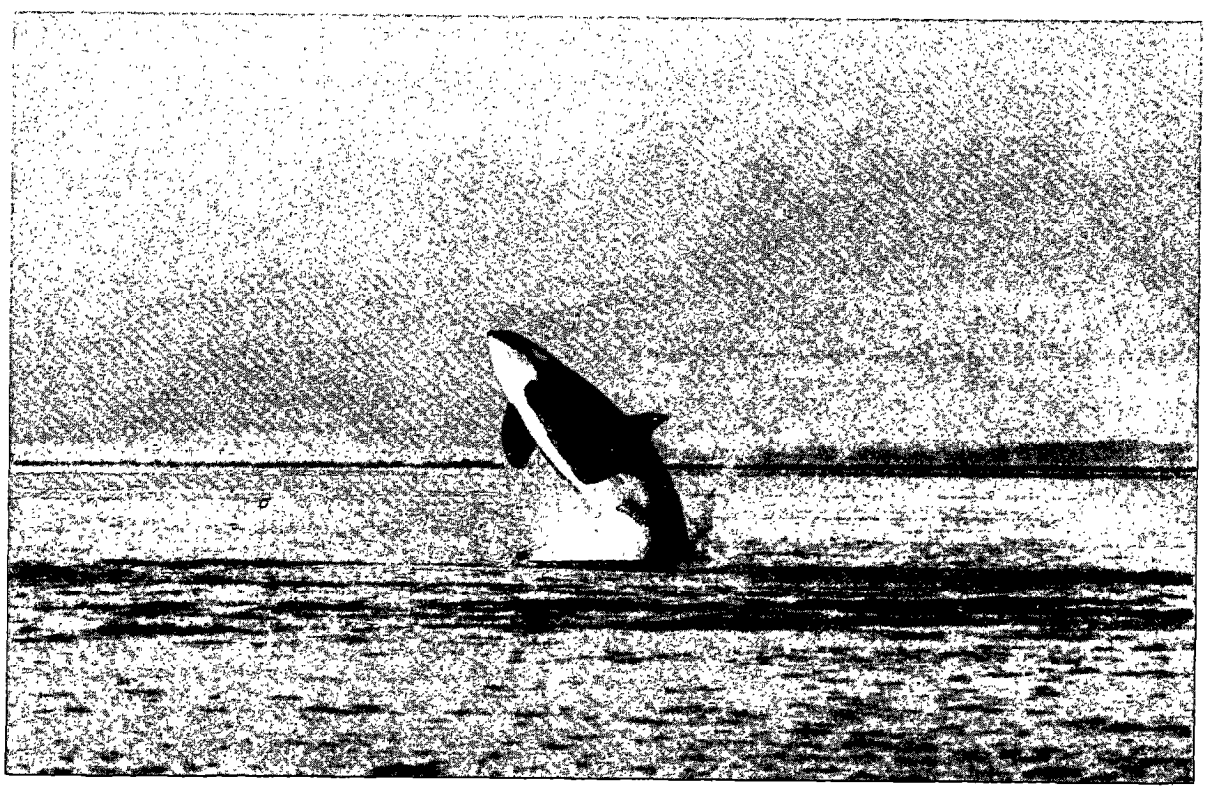
Humpback whale



Killer whale

33. KILLER WHALES

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 subadult males. The genus Orcinus is considered monotypic with geographical variation noted in size and coloring. Differences in call repertoires between pods and overlapping color patterns within pods indicate some isolation among pods. Chromosomal and biochemical evidence further 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 offshore 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 off Southeast Alaska, in Prince William Sound, near Kodiak Island, and in the southeastem 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. Multipod 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. 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 year-round in one area (encompassing several hundred square miles) and are dominated by strong matriarchal lineages. The natural mortality rate of killer whales is estimated to he less than 5% per year and frequently as low as 1% per year.

Movements of whales are believed to be related to the availability of prey, such as spawning salmon, and the movements of seals and whales. Killer whales prey on cod, Pacific herring, flatfish, and sablefish (also known as blackcod), 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, however, have been documented between killer whales and the sablefish fishery in the southeastern Bering Sea and Prince William Sound. Between 1985 and 1987, 7 killer whales from a resident pod of 35 were observed taking sablefish off fishermen's longlines. The seven killer whales 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 the Bering Sea and the rest of the whales' northernmost range.

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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 and seasonal movements, there may be four stocks: 1) in 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 for rearing calves. Most of the western North American stocks in Alaskan waters are associated with offshore wintering areas, although year-round concentrations occur in the southern Chukchi Sea, Bering Strait, Bristol Bay, and 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 breakup of ice and the arrival of spawning fish such as Arctic cod (Boreogadus saida), smelt, Pacific 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 average between 1 and 2 years.

The minimum estimated total population in Alaskan waters is 15,800-18,450, 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, presumed victims of fishing (based on net scars); 12 were caught in salmon gill nets. Up to five belugas per year have been reported taken in the salmon gill-net fishery in Cook Inlet.

Only indigenous people of Alaska are allowed to hunt belugas. Subsistence takes occur in western Alaska (especially in the northern Bering Sea and Chukchi Sea), along the Soviet coast and far east coast of Chukotka, and in the western Canadian Arctic Ocean (eastern Beaufort Sea). The estimated total kill (landed, struck, or lost) in U.S. waters and the Canadian Beaufort Sea exceeds 800 per year (based on data from the 1970s and 1980s), although the precise annual take is unknown. Most or all of these animals probably come from the same population that winters in the Soviet 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 struck is also unknown.

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35. DALL'S PORPOISE

Dall's porpoise (Phocoenoides dalli) is 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 Ocean. All-gray and all-white animals, a presumed fourth morph, are very rare.

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 Ocean 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 Ocean, but specific areas have not been proposed. The reproductive cycles of animals in the Bering Sea and western North Pacific Ocean are apparently out of phase, further supporting the stock separation hypothesis.

Throughout most of the eastern North Pacific Ocean, Dall's porpoise are present during all months of the year, although there may be seasonal inshore-offshore and north-south movements off Alaska, such as out of Prince William Sound and areas in the Gulf of Alaska and the Bering Sea. Based on studies carried out between 1978 and 1987, the minimum estimated total abundance of Dall's porpoise in the Bering Sea and the North Pacific Ocean (except the Sanriku coast stock) is 1.5 million; a recent analysis suggests, however, that this estimate may be too high by as much as a factor of 3. Further analyses on these data are under way. The Japanese high seas salmon mothership fishery has been operating in the North Pacific Ocean since 1952. The estimated annual incidental take of Dall's porpoise by the Japanese in this fishery (1981-87) within the EEZ ranged from 741 (1987) to 4,187 (1982). The mean take rate for observed salmon gill-net operations from 1981 to 1985 was 9.47 porpoise per set (15 km of net) inside the EEZ. The estimated incidental catch outside the EEZ rangedfrom 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 of Dali's porpoise by the Japanese squid fishery was reported by the Fisheries Agency of Japan to be 2,509 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.

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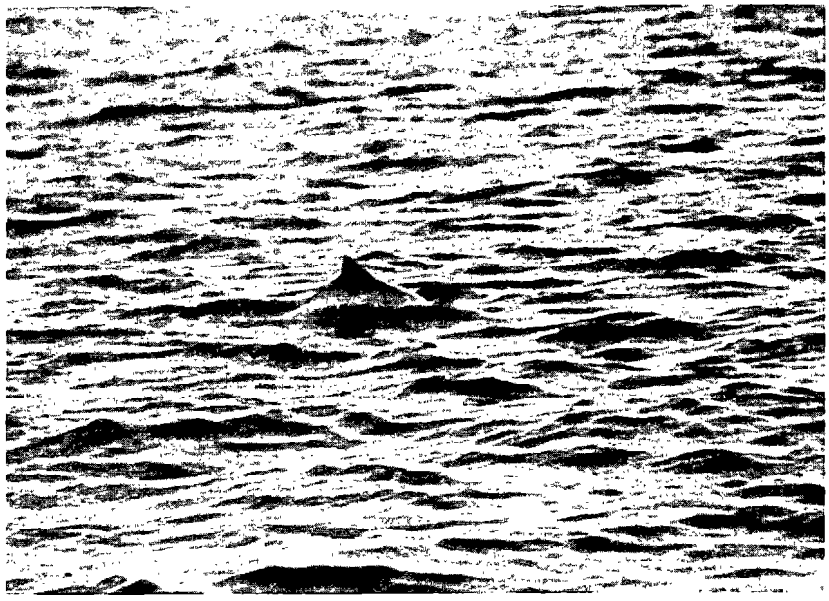
36. HARBOR PORPOISE

Harbor porpoise (Phocoena phocoena) in the eastern North Pacific Ocean range from the Beaufort Sea, Alaska, to the waters off Point Conception, California., although records of harbor porpoise from Los Angeles Harbor also exist.

The smallest of the North Pacific porpoises, Phocoena, is less that 6 feet long, dark gray 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 on euphausiids and squids.

The total number of harbor porpoise in Alaska is unknown. Systematic surveys for other cetaceans have frequently included harbor porpoise sightings. One of these surveys noted seasonal peak of over 500 animals in Prince William Sound 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: 1) northern Bering Sea and adjacent arctic water stock, 2) Aleutian Islands and southern Bering Sea stock, and 3) Gulf of Alaska and Southeast Alaska stock. 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 assess the status of the harbor porpoise in Alaska. A single incidental capture from the Bering Sea was reported in 1982, and 11 were reported taken from the Bering Sea during high seas gill-net 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.

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37. NORTHERN SEA LION

The northern sea lion (Eumetopias jubatus), also known as Steller's sea lion, is endemic to the North Pacific Ocean. Its range is from the Kuril Islands, U.S.S.R., to California, north to lat. 63°N and south to lat. 33°N. A total of 50 breeding rookeries have been identified throughout the species range (except in Washington). Northern sea lions exhibit strong site fidelity and generally disperse after reproduction; they do not migrate. Pupping peaks in mid-June, and lactation lasts 3 months to over 1 year. Sexual maturity occurs at age 4-6 years in females; gestation lasts 9 months after a 3-month delayed implantation. The mating system is polygamous.

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

A decline in abundance of northern sea lions was first noticed in 1976. Since the late 1960s, the species has declined by about 70%, with the largest decline occurring in Alaska. From the Gulf of Alaska to the Aleutian Islands, the sea lion population declined from 67,617 counted in 1985 to 29,804 in 1990--a decrease of 56% in just 4 years. The greatest decline has occurred in the eastern Aleutian Islands (94% decline), the former center of the species' abundance. During the 1980s, abundance in all areas of the species' range declined except in Southeast Alaska and Oregon.

It is unclear why the decline has occurred and whether it is directly or indirectly related to commercial fishing activities, disease, or from some unknown natural environmental factors. Food availability is considered, to be one plausible hypothesis.,,. Incidental take in foreign trawl and joint venture trawl pollock roe fisheries in 1973-88 may have also played an important role in the decline in the 1970s, and regionally in the early 1980s. Other factors such as redistribution, predation, native subsistence harvests, and entanglement in nets and debris are not significant in the decline. Intentional shooting may have been important at various times in some areas in Alaska.

In 1990, the northern sea lion was listed as a threatened species under the ESA. Since then, Federal action has been taken to restrict fishing and other boating activities near sea lion breeding sites and potential habitat important for feeding. Management actions now in effect are to assist recovery of the species. A recovery team has drafted a recovery plan to assist the NMFS in meeting its responsibilities under the ESA and MMPA. Fisheries activities now require consideration of the needs of northern sea lions and their habitat.

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

U.S.	1956-68	1975-77	1984-86	1989-90
Alaska	150,572	129,347	89,295	39,396
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.

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 north to the Okhotsk (U.S.S.R.) and Bering Seas (Alaska) 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 Komandorskiy, Pribilof (St. Paul and St. George Islands) and Bogoslof Islands (all in the Bering Sea); and on San Miguel Island (southern California).

Most mature northern fur seals are on or near their breeding islands from June to November and spend the remaining months at sea. Some immature seals do not return to their island of birth each year. Northern fur seals tend to concentrate along the continental shelf and slope where nutrient-rich waters support a variety of prey species. Northern fur seals have been seen far at sea and are occasionally taken in' high-seas drift 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 about lat. 36°N (off Honshu Island, Japan). The northern extent of the range is the central Bering Sea.

Older male fur seals (ages 10-15 years) from the Pribilof Islands winter farther north in the North Pacific Ocean than younger males and females. During their southbound migration, females and young males occur over the continental shelf off Canada and Washington State 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 of females and some immature males occur between California and British Columbia. The spring migration from the southern wintering areas begins in March; the majority of the seals follow the continental shelf northward then westward through the Gulf of Alaska and into the eastern Bering Sea through eastern Aleutian Island passes. Older males (10-15 year olds) usually arrive first on the islands in May and are followed by the mature pregnant females by late June. Immature

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 population size on the Pribilof and Bogoslof Islands in 1988 was 871,000; 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, and in the 1980s through 1990, show that: 1) pup production on St. Paul Island is down by about 60%; 2) the number of territorial males with females on St. Paul Island is down about 63%; and 3) rookery space occupied on St. Paul Island in 1985 was less than one-third that in 1948.

The preexploitation level of northern fur seals is unknown; the best estimate is that the Pribilof Islands population originally numbered between 2 and 3 million prior to the 19th century. By the early 1950s, the Pribilof herd was believed to be approaching that level and was probably close to the carrying capacity of the ecosystem. Females were spared during harvesting from 1917 through 1955 during the period of rapid population recovery. Starting in 1956 and ending in 1968, a harvest of females from the Pribilof Island population contributed significantly to a decline in the population. A second decline in the Pribilof herd began in 1975 from unconfirmed causes but may have ended by the early 1980s. The current rate of growth of the herd is not significantly different from zero, although pup production on St. George Island is declining at 6% per year.

Fur seals are caught incidentally in the high-seas foreign drift 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 effort). Fur seals are also occasionally taken in domestic trawl and longline fisheries. Three fur seals were taken in trawl nets in 1990: two were released alive and the other was decomposed.

The Pribilof Islands population of northern fur seals was declared depleted under the MMPA in 1988. This action was taken because the population was below half of the estimated maximum net productivity level (MNPL) of 60% (or more) of the population size in the 1950s. Biological indices (body size, pup survival), used to help assess the status of the population relative to its carrying capacity, indicated that current population levels are about as far below the current carrying capacity as they were below mean population levels in the 1940s and 1950s. This implies that carrying capacity for fur seals has not changed dramatically over the past 50 years, and that possibly external factors have caused the Pribilof Islands population to decline.

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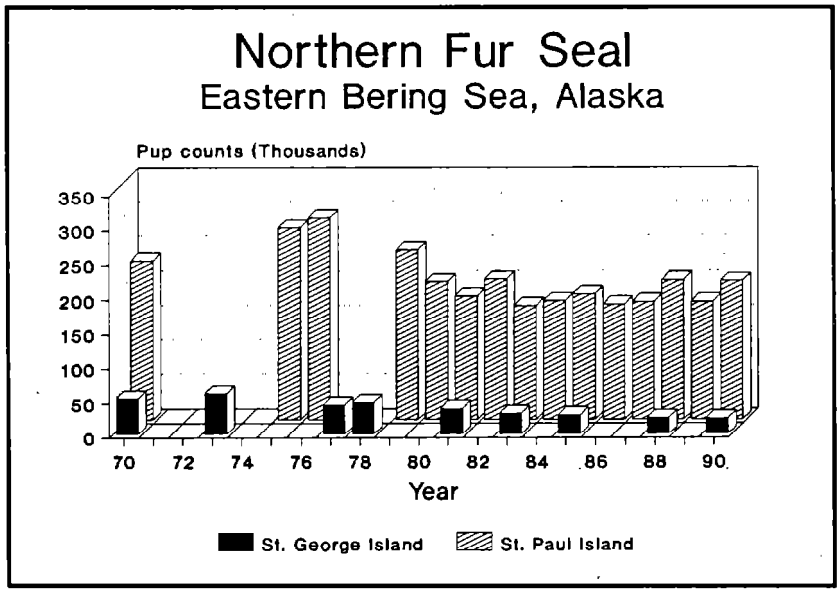

39. HARBOR SEAL

Harbor seals (Phoca vitulina richardsi) in Alaska range from Southeast Alaska to the central Bering Sea (to about lat. 59°N). They are commonly seen in coastal and inland waters where they haul out on sand bars and rocky shores to give birth, molt, and rest. They can also occur at sea.

Harbor seals give birth to a single pup after a gestation of 11 months. 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 also unknown. Studies conducted in the 1970s and 1980s on Tugidak Island (southwest of Kodiak Island, western Gulf of Alaska) indicate that the population there declined 86% over a 15-year period, from 6,919 in 1976 to 960 in 1990. Similar trends may be occurring at other areas of Alaska but studies needed to determine the extent of the decline only began in 1991.

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 setnet fisheries in the Copper River delta, Prince William Sound, and Unimak Pass area only began in 1989. The extensive net fisheries in other Alaskan waters have not been monitored.

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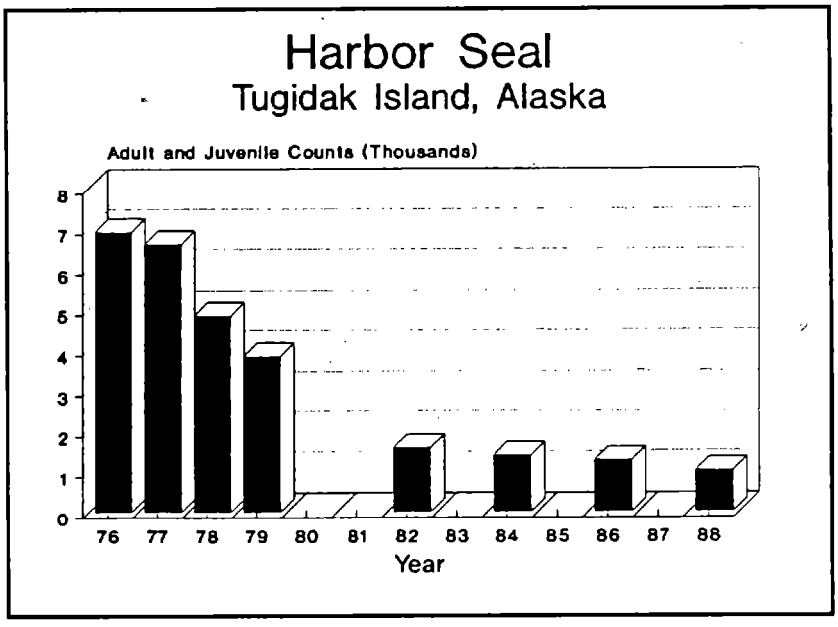
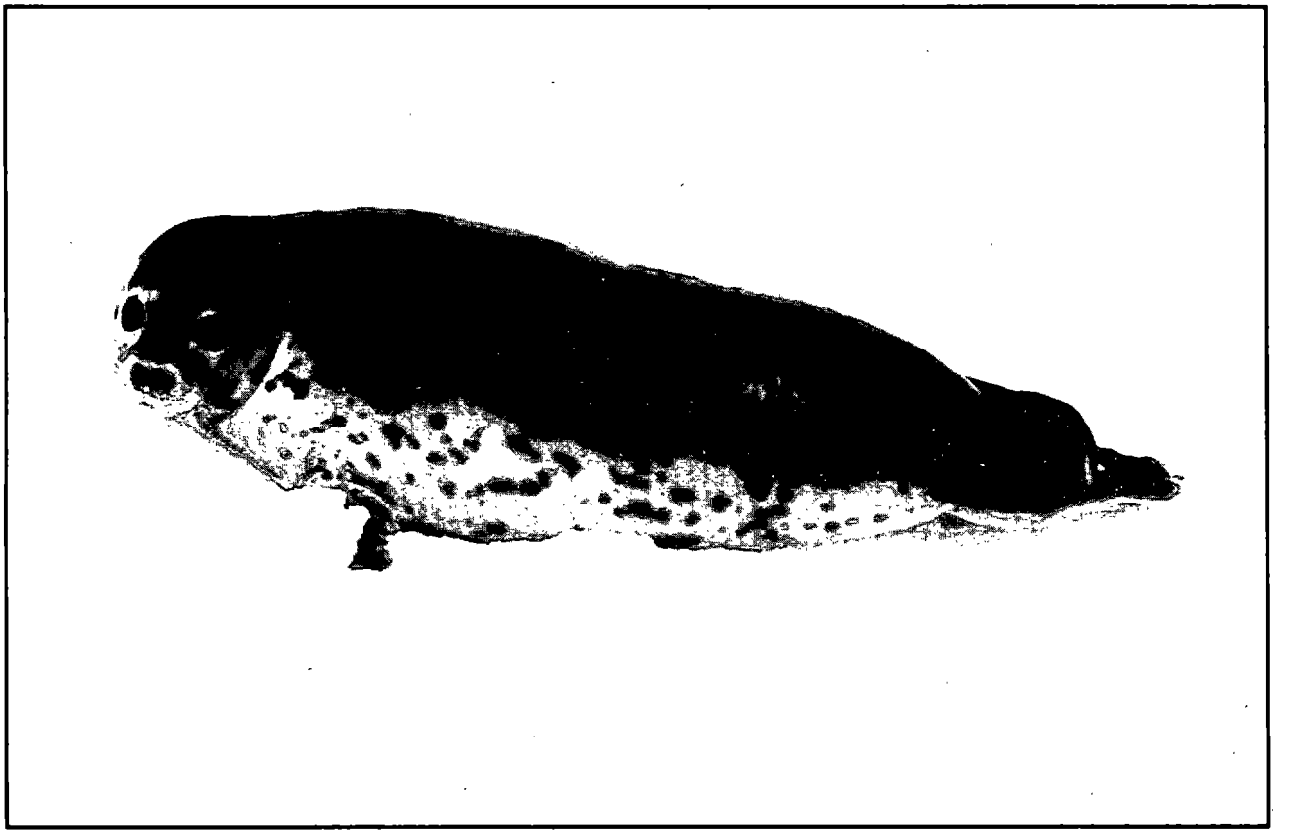


40. SPOTTED SEAL



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, of which three occur in the Bering&a: 1) Bristol Bay to the Pribilof Islands; 2) Navarin Basin to the Gulf Anadyr (U.S.S.R.); and 3) eastern Kamchatka Peninsula (U.S.S.R.), from Karaginskii Bay to Olyutorski Gulf and north into the northern Bering Sea. There are few morphological differences between the animals from the eight areas, indicating that if they have been separated it has been only for a short time.

Spotted seals are Usually associated with the southern extent of the arctic pack ice in winter and spring, but they haul out on land in the northern part of the range in summer and autumn. 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 post-partum. During this period, adults are seen on ice floes as female-pup or male-female pairs, or male-female-pup triads. Subadults and nonbreeding animals are generally found in larger groups. In the southeastern Bering Sea, herds of spotted seals are found in proximity to walleye pollock concentrations.

Molting occurs during late spring. Although some seals molt on land on the eastern Bering Sea coast, loose groups of up to 200 animals are generally found among the ice remnants. 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 haul-out sites.

The current abundance of spotted seals in Alaska is unknown. In 1973 the Bering Sea population of spotted seals was estimated to have been 200,000-250,000 ani-

mals, although 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.

Spotted seals are likely to interact directly with both the commercial groundfish and herring fisheries based on the seal's diet, utilization of the Bering Sea for feeding, foraging strategy, and their distribution. U.S. fishery observers on foreign independent fishing vessels and joint venture motherships 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.

Spotted seals taken incidental to domestic groundfish, herring, and Pacific salmon fisheries are usually unreported. Commercial fishermen may, on occasion, deliberately kill seals because of their potential destruction of fishing gear (especially gill nets), damage of fish in nets, and competition for fish. No data are available to assess these takes. The magnitude of spotted seal mortality from incidental take and entanglement is unknown. However, other phocid seals such as harbor seals, elephant seals (Mirounga angustirostris), and Hawaiian monk seals (Monachus schauinslandi) have been observed to become entangled at rates comparable to otariids.

During the 1960s and 1970s, Soviet commercial sealing and Alaskan Eskimo subsistence harvests averaged about 4,000-8,000 spotted seals per year in the Bering Sea or about 3% of the juvenile and adult population. However, subsistence hunts have apparently declined in recent years.

Walleye pollock, capelin, Arctic cod, and Pacific herring are major prey items for spotted seals in the Bering Sea. The importance of competition between these seals and fisheries cannot be assessed, however, because data on the population dynamics and behavior of spotted seals are lacking.

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