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Status of Living Marine Resources off the Pacific Coast of the United States for 1993

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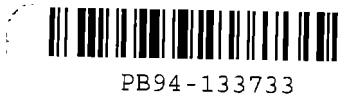

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C O N T R I B U T O R S

This report has been the joint effort of two Fisheries Science Centers of the National Marine Fisheries Service that are located on the Pacific Coast: the Alaska Fisheries Science Center in Seattle, Washington, and the Southwest Fisheries Science Center in La Jolla, California. The following personnel were the major contributors for this report:

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O V E R V I E W

By Loh-Lee Low

Photo: AFSC

Status of Stocks off the Pacific Coast

This report provides a species-by-species description of the status of living marine resources off the Pacific Coast of the United States as assessed through 1992. 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. It is one of a series of regional reports on the status of living marine resources throughout the United States.

The resources are grouped under four major headings: groundfish resources, pelagic resources, Pacific salmon. and marine mammals. There are other resources of commercial and recreational importance that are not included in this report these are mostly inshore marine resources under the jurisdiction of the Pacific Coast States of Washington, Oregon, and California.

National Marine Fisheries Service Science Centers

There are three Science Centers of the National Marine Fisheries Service that have research responsibilities in the Federal waters and rivers of the US. West Coast. They are the Alaska Fisheries Science Center and the Northwest Fisheries Science Center, located in Seattle, Washington: and the Southwest Fisheries Science Center, located in La Jolla, California.

The region is bounded on the north by the Canadian border and on the south by the Mexican border. The range encompasses cold temperatures to the north and warm subtropical waters to the south and open waters toward the Hawaiian Islands.

The region supports important commercial fisheries for Pacific salmon, Pacific halibut, Pacific whiting, anchovy, sablefish, flounders, and rockfishes. The region also supports important tuna fisheries and popular sport fisheries for Pacific salmon, halibut, steelhead trout, and billfishes. It is home to and an

Pacific Coast Groundfish Resources

Species	Recent Average Yield (t) (1990-92)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Pacific whiting	197,000	141,600**	176,800**	full
Dover sole	15,330	15,900	16,300	full
Other rockfish	13,580*	14,000	unknown	unknown
Widow rockfish	9,534*	7,000	6,800	full
Sablefish	9,580	7,000	6,900	full
Other fish	6,300	unknown	unknown	unknown
Thornyheads***	7,515	7,000	8,500	full
Yellowtail rockfish	4,800	4,600	6,400	full
Chilipepper	3,231*	3,600	3,600	full
Lingcod	3,048	7,000	unknown	unknown
Canary rockfish	2,300	2,900	3,500	full
English sole	2,170	1,900	unknown	full
Bocaccio, CA & S. OR	2,540*	1,540	1,770	full
Petrale sole	1,930	1,100	unknown	full
Pacific cod	1,680	3,100	unknown	full
Pacific ocean perch	1,125	0	3,000	over
Shortbelly rockfish	5	13,000****	18,500	under
Total less whiting	84,668	95,940	108,670	full
Total with whiting	281,668	237,540	285,470	full

*1989-1991 data.
**U.S. potential yield set at 80% of coastwide Acceptable Biological Catch (ABC)
***central California - central Washington only
****interim ABC set at 13,000 t; CPY may be 61,500 t
Note: totals based on RAY if CPY or LTPY is unknown

Pacific Coast Pelagic Resources

Species	Recent Average Yield (t) (1989-91)	Current Potential Yield (t)	Long-term Potential Yield (t)	Status of Utilization
Northern anchovy (U.S.)	8,260	4,900	219,000	full
Jack mackerel	12,200	52,600	100,000	under
Pacific mackerel	36,400	29,000	29,000	full
Pacific sardine (U.S.)	6,030	27,000	250,000	full
Pelagic Subtotal	62,890	113,500	598,000	full

Pacific Salmon off Washington, Oregon, and California (In 1,000s of fish)

Species	Recent Average Yield (1990-92)	Current Potential Yield	Long-term Potential Yield	Status of Utilization
Pink	3,191	3,496	3,496	Over
Coho	2,184	3,231	3,231	Over
Chinook	1,169	2,274	2,274	Over
Sockeye	1,524	1,788	1,788	Over
Chum	1,017	1,017	1,017	Over

important migratory area for a wide array of marine mammal species (e.g., gray whale, California sea lion, killer whale, and dolphins).

The mission of the NMFS Science Centers is to conduct 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 Centers provide scientific data and technical advice to their constituents for better utilization and management of the Nation's living marine resources. Their primary constituents are the Pacific. North Pacific, and Western 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.

Pacific Coast

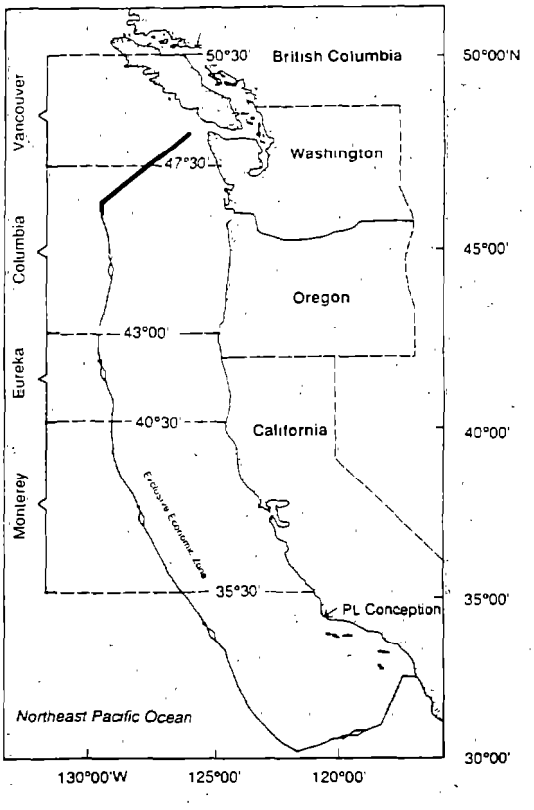
Groundfish Resources

Pacific Coast groundfish constitute a diverse group of fish species harvested in the Exclusive Economic Zone (EEZ) off Washington, Oregon, and California. This group of 83 species is managed by a Federal fishery management plan (FMP). the Pacific Coast groundfish FMP, through auspices of the Pacific Fishery Management Council (PFMC).

Groundflsh are harvested primarily with trawl gear. The total commercial catch in 1992 was about 276,000 metric tons (t), with an ex-vessel value of approximately $88 million. Commercial landings in recent years have been dominated by Pacific whiting. That species constituted approximately 70% of the landings and 25% of the value in 1992. Other species/categories which were important in the landings included Dover sole (6%), thornyheads (3%), sablefish (3%), widow rockfish (2%). and yellowtail rockfish (2%). Arrowtooth flounder, canary rockfish, and unspecified rockfish were each 1-2% of the commercial catch. The recreational catch in 1989, the last year with available data, was about 7,000 t, primarily rockfish.

Most major species of West Coast groundfish are fully utilized. Stock assessments generally indicate that the surplus biomass has been removed from most of the long-lived stocks (e.g.. sablefish. Dover sole, several rockfish species). The current potential yield (CPY) is 17% below long-term potential yield (LTPY). The potential yield for Pacific whiting experiences the greatest degree of natural variability. Stocks of Pacific ocean perch and bocaccio need to be rebuilt following depletion by foreign fishing and a series of weak year classes, respectively. One species is underutilizd: the shortbelly rockfish. It is a midwater or semidemersal rockfish with a relatively large biomass, but a market has not yet developed. Management of jack mackerel, also lightly utilized, is currently being transferred from the Groundfish FMP to a new Coastal Pelagics FMP.

The recent average yield (RAY) of Pacific whiting is 197,000 t, more than ten times greater than the RAY of any other species. Dover sole, widow rockfish, and sablefish are a second tier grouping with a RAY of 9,000-15,000 t per year. In 1990, thornyheads (two species of deepwater rockflsh) moved into this second tier with landings of 10,000 t, although this declined to about 8,600 t in 1992. The third tier grouping, with annual landings of 1,000-6, t, contains several species. The major rockfish species in this third tier are yellowtail rockfish. canary rockfish and Pacific ocean perch in the Vancouver-Columbia INPFC areas (approximately Washington-Oregon), and bocaccio in the areas off California and southern Oregon. Other.



International North Pacific Fisheries Commission Statistical (INPFC) Areas off the coasts of the United States and Canada-

rockfish species contribute 13,600 t per year to the commercial catch, and the recreational catch of all rockfish species has been estimated to be 5,000 t per year. The flatfish species in this third tier are English sole and petrale sole. In addition, a large fraction of the category "other fish" is now composed of arrowtooth flounder, harvested primarily off northern Washington. Finally, lingcod and Pacific cod contribute 3,000 t and 1,900 t, respectively.

A difficult management problem which generates a high level of public involvement is allocation of the availabbe catch. The Council faces U.S.-Canada allocation of Pacific whiting, onshore-offshore allocation of whiting, fixed gear-trawl allocation of sablefsh, and recreational-commerci competition for some rockfish. Technical analysis of these issues generally rests on an economic analysis that rarely includes adequate information on all sectors of the fishing industry. For some of these problems, individual transferable shares have been identified as a potential long-term solution.

Probably the most severe problem facing managers of the Pacific Coast groundfish fishiery is control of the excess harvesting capacity. Today, this problem is manifested as increasingly severe trip limits that cause frustration for fishermen. managers, enforcement agents, and biologists. Tomorrow, the problem could be unexpected stock declines caused by unmonitored discard The license limitation program, scheduled for implementation in January 1994, is a first major step towards alleviating the problem of excess effort Both allocation and effort control problems are exacerbated by the complex multi-species nature of the fishery.

Pelagic Resources

Major pelagic resources (northern anchovy, Pacific mackerel. jack mackerel, and Pacific sardine) that occur in commercial quantities off the Pacific coast are known collectively as "coastal pelagic species." Northern anchovy, Pacific mackerel, and sardine occur primarily off California while jack mackerel is distributed from Baja California, Mexico, north to Alaska, with main spawning grounds and most of the harvest occurring off California. Coastal pelagic species are taken predominately with purse seines off southern California. Jack mackerel are currently underutilized while the other three species are fully utilized.

The northern anchovy is exploited by fisheries in both Califomia and Mexico. Anchovy fisheries in the United States have been managed by the PFMC since 1978. Current regulations impose no numeric limit on live bait catch and provide a 7,000 t quota for other nonreduction uses. The regulations also specify optimum yield for the reduction fishery as 1) zero when the spawning biomass is less than or equal to a cutoff level of 300,000 t, and 2) the difference between the Spawning biomass and the cutoff, up to a limit of 200,000 t, when the spawning biomass is greeter than 300,000 t The biological rationale for the 300,000 t threshold in the optimum-yield formula for reduction fishing is to prevent depletion of the resource and to provide an adequate forage reserve for marine fish, mammals, and birds. In the absence of a bilateral agreement with Mexico, fishery managers in the United States assume that U.S. fishermen are entitled to 70% of the total optimal yield and set quotas on this basis (e.g., 70% of 7,000 t or 4,900 t for the U.S. nonreduction fishery).

Pacific (chub) mackerel supports Califoinia's most important pelagic fishery and has been the mainstay of the purse-seine fleet in recent years. The Pacific mackerel is harvested by commercial fisheries in California and Mexico and is sold fresh, canned for human consumption and for pet food, and is also reduced to fish meal and oil. The U.S. Pacific mackerel fishery is managed by quotas that are set at 30% of the biomass over 18,000 t, and there is no quota when the biomass exceeds 135,000 t Commercial catches in the United States have been steady since 1980. while Mexican catches have recently increased.

Pacific sardine supported the largest fishery in the Western Hemisphere (25% of all fish landed in the United States) during the 1930s and early 1940s. when abundance may have been as high as 3.5 million t. Catches and abundance of Pacific sardine declined after the Second World War until the fishery collapsed in the early 1960s. A complete moratorium on sardine fishing was imposed in Califomia during the 1967-1968 season due to low biomass levels. During 1986 to 1990, after abundance had increased somewhat, small quotas were allowed for commercial harvest in California. In 1991, the California quota was increased to 27,000 t in response to increased biomass levels. The U.S. quota in 1991 was intended to allocate half of surplus production to the U.S. and Mexican fisheries and half to rebuilding the stock. Mexican landings

since 1983, which have not been managed by quoq increased dramatically in 1991.

The jack mackerel is similar to several other species of *Trachurus* (horse mackerel) which occur in temperate eastern boundary currents worldwide. Jack mackerel (particularly offshore and northern segments of the stock) are underutilized. The southern California segment of the stock has been fished since the late 1940s and fishing continues at a low level. Some interest has been expressed in developing an offshore fishery, but no fishery has yet emerged.

Currently, the northern anchovy is managed under a separate FMP and jack mackerel north of lat 39° N is managed under the FMP for groundfish (harvest south of lat. 39° N is not regulated). Pacific mackerel and Pacific sardine are managed by the State of California All four pelagic species will soon be managed under a new FMP for coastal pelagic species that is under development by the PFMC. The new plan will likely include a license limitation program to help manage the growth of fishing effort in this fishery. Lack of a cooperative management agreement with Mexico is the most significant problem affecting management of northern anchovy, Pacific sardine, and Pacific mackerel.

Salmon Resources

There are five species of Pacific salmon native to Washington, Oregon, and California sockeye, chinook, pink, chum, and coho salmon. Salmon are anadromous species -- they spawn in freshwater, migrate and rear in the open ocean, and return to the home stream or lake to repeat the life cycle.

The Pacific salmon fishery contributes significantly to the food supply, economy, and recreational fishing industry all along the Pacific Coast. It has always been an integral part of the culture and heritage of the Pacific Northwest Although most of the salmon are caught in commercial and Tribal fisheries, a significant portion are caught by recreational fishermen.

The combined commercial landings in recent years of all species had an annual ex-vessel value of about $140 million. It is much more difficult to place a value on the recreational fishery since there is not a consensus on how to do this precisely. Some sport-caught salmon have been valued as high as $295 per fish. Nevertheless, it is obviousthat the average recreational catch for the past 3 years of 1.2 million' salmon would be worth many millions of dollars annually.

The summary table on Pacific salmon includes production data of both hatchery and natural spawners. Although the yield for each species will vary annually; pink, chum and sockeye are not expected to deviate much from recent year averages. For all five species, there is excess fishing capacity and severe limitations on fishing are required to protect the stocks. For this reason, all species are listed as overutilized.

Management of the Pacific Coast salmon resources is rather complex, with a number of agencies being involved. Since Pacific salmon migrate long distances in the ocean across geopolitical boundaries, they are affected by management concerns of the U.S.-Canada Pacific Salmon Commission (PSC), the State fishery agencies, Tribal management entities, and the PFMC.

Sockeye, Pink, and Chum Salmon

These species are not managed under a federal FMP. Overall management of these three species rests primarily with the PSC and State and Tribal fishery agencies.

The U.S. stocks of pink, sockeye, and chum salmon appear to be fairly stable, fluctuating in abundance in response to variable annual survival rates. Some U.S. catches of sockeye and pink salmon are dependent on stocks originating in the Fraser River of Canada The number of these fish that U.S. fishermen can harvest is limited under terms of the U.S.-Canada Salmon Treaty signed in 1985, which covers the salmon fisheries from Southeast Alaska to northern Oregon.

One stock of special concern is the sockeye salmon run from the Snake River. This stock has been listed as endangered under the U.S. Endangered Species Act (ESA) of 1973. In 1988, there were four adults and two redds reported in the spawning escapement; in 1989, one adult, one redd and a second potential redd; and in 1990, no adults or redds were identified. In 1991, the run consisted of three males and one female. In 1992, there was just one lonely and extremely disappointed male. The depressed condition of this stock is almost certainly due to the destruction of the freshwater habitat and the construction of several dams on the Columbia and Snake Rivers. These increased hazards and changes in the freshwater habitat have caused the virtual demise of these fish.

Chinook and Coho Salmon

These species are managed by a federal FMP through auspices of the PFMC. The management is guided by Judge Boldt's ruling in the early 1970s that entitled Treaty Indians up to 50% of the catch of salmon runs returning through the Indians' "usual and accustomed" fishing areas. With Tribal fisheries occurring in inland rivers and Puget Sound as well as in the ocean, designing fishing seasons that properly achieve treaty rights and still maintain adequate escapements has been very difficult and has resulted in a significant shift of catch from the ocean fisheries off Washington to inland fisheries. Currently, management of catches is achieved primarily via catch quota allocations to various user groups.

One major change to the landings was the change from natural production to hatchery production. Whereas the early landings were entirely from natural spawning stocks, in recent years, a large share of the production has been from hatchery fish. This is particularly true for coho salmon. Although hatchery fish can be used to supplement natural production, they also may compete with or even replace natural spawners. Thus, there is some concern about the relationship between natural and hatchery fish.

A petition was received in June 1990 to list lower Columbia River natural coho as-endangered, and this stock has been declared extinct. In view of the large production of coho from hatcheries on the Columbia River, the management of Columbii River coho salmon has been directed toward harvesting these hatchery fish to prevent wasting large numbers of who returning in excess of hatchery needs.

Petitions have also been received for listing the spring, summer, and fall chinook salmon stocks from the Snake River as endangered under the ESA. The Snake River spring/summer run has been listed as a single threatened species, and the fall run has also been listed as threatened In 1990, the Sacramento winter-run chinook salmon stock was listed as threatened

After receiving a petition from the American Fisheries Society in June 1991 to reclassify the winter run, NMFS reviewed the status of the run. and in June 1992, a proposal to reclassify the run as endangered was published A final decision is expected any time. The opinion of NMFS is that since the PFMC has already consulted with NMFS when the run was listed as threatened, and a "no jeopardy" opinion was issued, upgrading the listing will not place additional constraints on fisheries nor require reinitiation of consultation. If a species is listed as endangered, it could have very severe ramifications not only to salmon management, but also to other industries.

Many other chinook salmon stocks are also depressed, with declining escapement and/or failure to meet escapement goals. Some examples are Shasta River chinook salmon, Klamath River chinook salmon, and the spring/summer chinook salmon stock above Bonneville Dam. For all the upper Columbia River salmon stocks. the changes in the freshwater environment have had a devastating effect on their survival. The large number of dams that have been built one very visible factor. Dams that are passable to salmon still take their toll on returning adults and of 'course, there are completely impassable dams that have eliminated large spawning areas. Also, conditions at dams cause significant losses of downstream migrating young salmon through delayed migrations and mortality from passing through the turbines. The lack of adequate water for fish passage has been a problem. Here again, elimination of some of these devastating factors and improvement of the freshwater habitat are needed if these stocks are to be restored.

Marine Mammal Resources

Fifty-two species of marine mammals in U.S. waters are under the jurisdiction of the Department of Commerce. This includes 40 species of whales, dolphins and porpoises, and 12 species of seals and sea lions.

Fourteen of the most commonly observed species 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 mammal species make long-distance migrations or move hundreds of miles within smaller areas of the ocean between seasons of the year. Whales and dolphins often navel from one feeding ground to another or spend the breeding season in lower latitudes and the major feeding and calf-rearing seasons in higher latitudes.

Thirty-five species of marine mammals reside or seasonly occur in waters along the coast of Washington, Oregon and California. There are several populations of marine mammals that spend the majority of the year in California waters: offshore waters of Washington and Oregon are generally transition areas for animals moving between the southern breeding grounds off Mexico and Califor-

Status of Selected Species of Marine Mammals off Washington, Oregon, and California.

Species	Abundance	Trends (+/-%)
Gray whale	20,869	+3.3%/yr (1968-88)
Humpback whales	1,398-2,040	Unknown
Killer whale (Puget Sound)	146	Stable?
Delphinid complex*	>150,000?	Unknown
Vaquita	< 100?	Declining
Harbor porpoise	50,000	Unknown
California sea lion	>110,000	Increasing
Northern sea lion	~5,000	Declining
Northern fur seal	~6,000	Increasing
Harbor seal	75,776	Increasing
Elephant seal	73,300	+6.7%/yr (1981-91)

(e)=endangered; (t)=threatened; (d)=depleted.
* Short-finned pilot whale, northern right whale dolphin, bottlenose dolphin, white-sided dolphin, common dolphin, and Grampus, mostly off California.

nia, and rich feeding grounds off Alaska. A few species such as the harbor porpoise and Pacific harbor seal are found year-round in Washington and Oregon, but this is also true for these species in California and Alaska. These unique differences within and between species have led to unique life-history strategies and result in the need to manage several species, populations or stocks.

Management of marine mammals is carried out under the Marine Mammal Protection Act (MMPA) of 1972 and the ESA. Both Acts require that management of marine mammals be based on the identification and enumeration of populations or stocks.

Two species, the vaquita or Gulf of California harbor porpoise and the Guadalupe fur seal, are not endemic to the United States (although a few male. Guadalupe fur seals do occasionally show up in California). The two species are included in this report because of their rarity and the active conservation efforts carried out on them by the U.S. and, Mexican Governments.

A summary of the status of selected species is presented in the table above.

Glossary of Common Abbreviations and Terms

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

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

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

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

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

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

Mortality rats: 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-d&es 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. This instantaneous mortality is used

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

M-Natural mortality is the mortality due to natural causes.
F-Fishing mortality is the mortality due to fishing.
Z - Total mortality rate is the combined effect of all sources of mortality acting on a fish population. Thus Z=M+F.

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

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

F is the rate of fishing mortality when maximum sustainable yield for the stock is achieved.

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

F is the fishing mortality rate that reduces spawning biomass per recruit ratio to 35% of the unfished level. This rate has often been adopted by

the PFMC and NPFMC as the fishing rate to calculate ABC. The $F_{30\%}$ has often been adopted as the $F_{overfishing}$ rate.

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

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

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

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

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

Bringing in the catch

Photo: AFSC

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By Martin W. Dorn

Pacific whiting (Merluccius productus) also known as Pacific hake, is a migratory gadoid distributed along the west coast of North America from Baja California to Queen Charlotte Sound. Adult Pacific whiting migrate north in spring and summer to feed along the continental shelf and slope from northern California to Vancouver Island. Larger f&h tend to migrate farther north, In autumn, Pacific whiting migrate south to spawning areas from Point Conception to Baja California. The peak spawning months are January and February. Spawning occurs as much as 400 km offshore. Recruitment is extremely variable for this species: strong year classes are about two orders of magnitude larger than the weak year classes. Years with cold water temperatures in the winter months tend to have low mean recruitment, while warm years have higher though more variable recruitment

Asymptotic length is 56.3 cm for males and 61.2 cm for females. Annual variations in growth have been detected and appear to be related to changes in water temperature and the size of adult biomass. Most Pacific whiting are infected with a myxosporean parasite that releases enzymes after the

PACIFIC WHITING
Pacific Coast
COMMERCIAL CATCH (1,000 t)

	United States			Canada	TOTAL
	Foreign	Joint Venture	Domestic		
1983	0.0	72.1	1.1	40.8	113.9
1984	14.7	78.9	2.7	42.1	138.4
1985	49.9	31.7	3.9	25.0	110.4
1986	69.9	81.6	3.5	55.7	210.6
1987	49.7	106.0	4.8	73.7	234.1
1988	18.0	135.8	6.9	90.5	251.2
1989	0	195.6	7.4	99.5	302.5
1990	0	171.0	12.8	76.7	260.5
1991	0	0	204.2	104.5	308.7
1992	0	0	208.8	86.4	295.2

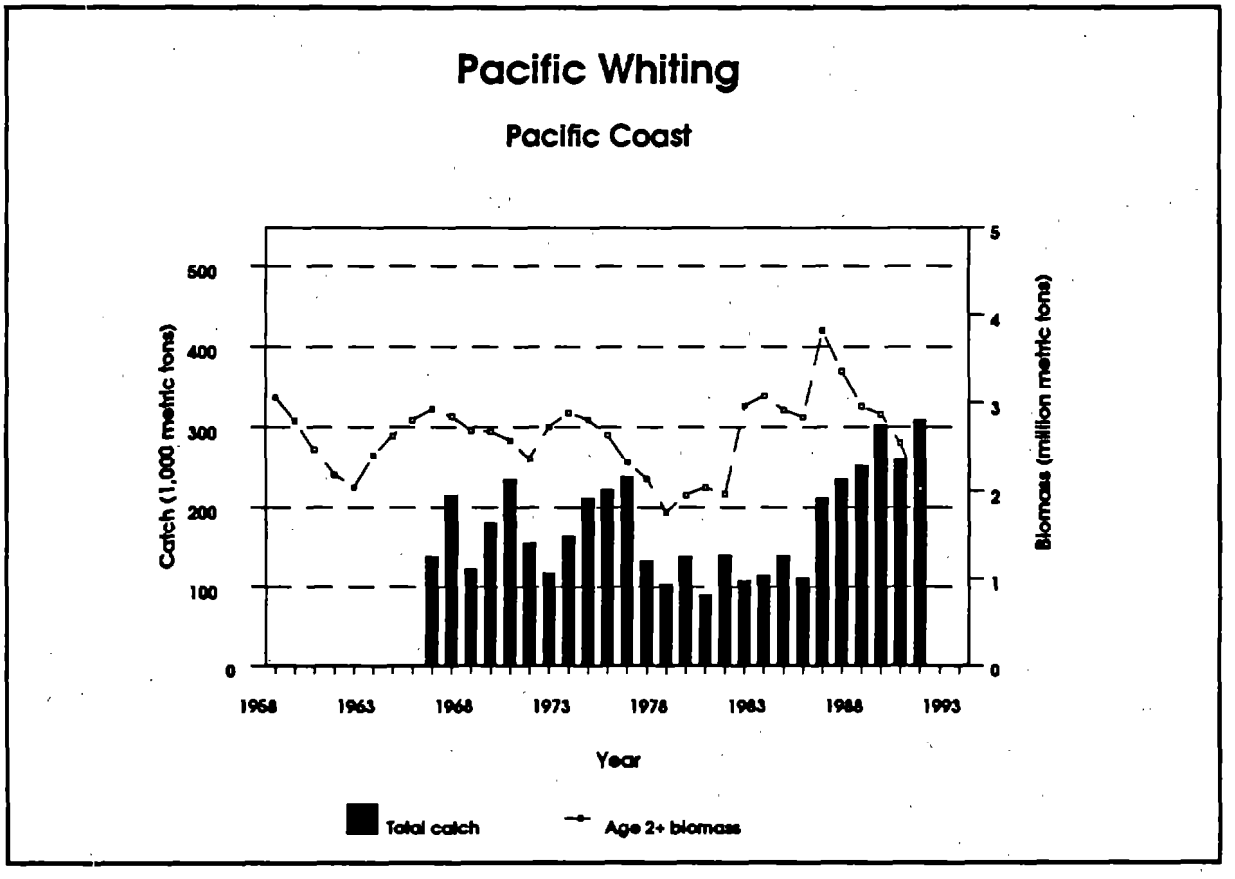
death of the fish, resulting in a rapid breakdown of the muscle tissue. Important items in the diet of Pacific whiting include euphausiids. shrimp, sand lance, eulachon, and herring. Significant predators on Pacific whiting juveniles include rockfishes, sablefish, and sooty shearwaters. The adults are preyed on by California sea lions, northern fur seals, and northern sea lions.

The midwater trawl fishery for Pacific whiting, operating in both U.S. and Canadian waters, targets on dense feeding aggregations of fish that occur along the shelf break from April to November. The fishery for Pacific whiting underwent a major transformation in 1991. The joint venture fleet, which accounted for most of the catch since 1982, was entirely displaced by a fleet of American factory trawlers and motherships built to participate in the walleye pollock fisheries in Alaskan waters. Landings in U.S. ports also increased in 1991 and 1992. The shoreside landings in 1991 were more than double the previous highest annual landings, and they doubled again in 1992, accounting for 25% of the total U.S. catch in 1992.

The lack of agreement on how to allocate the resource between the U.S. and Canada has made it difficult to follow the scientific recommendations for harvest rates in recent years. In the absence of an agreement, each side has tended to fall back on its negotiating position, with the result that the aggregate U.S. and Canadian catch has exceeded the PFMC recommended catch since 1990. In 1990, the ABC was exceeded by 6% and in 1991 the catch exceeded the ABC by 25%.

The coastal population of Pacific whiting has been surveyed every 3 years since 1977. The midwater component of the stock is surveyed using hydroacoustic methods, while the demersal component is surveyed by the multispecies West Coast triennial trawl surveys. The two components are assumed to be additive. The demersal component varies between 6% and 23% of the total biomass. The total biomass measured by the survey in 1989 was 1,637,000 t, a decline of 24% from the biomass measured in 1986.

Pacific whiting are assessed using the stock synthesis model, a separable catch-at-age analysis



PACIFIC WHITING
Pacific Coast, including Canada

Average catch (1983-92)	=	221,600 t
Long-term potential yield (MSY)	=	221,000 t
Acceptable biological catch (1993)	=	177,000 t
Importance of recreational fishery	=	Minor
Management	=	Groundfish FMP
Status of exploitation	=	Fully exploited
Age at 50% recruitment	=	4.4 years (males) 4.1 years (females)
Length at 50% maturity	=	Unknown (males) 38 cm (females)
Assessment approach	=	Age-structured, separable analysis
Fishing strategy	=	Variable F
F (1991)	=	0.17

that uses survey estimates of biomass and age composition as auxiliary information. The biomass of age 2 and older fish in 1991 was estimated to be roughly 2 million t The recruitment abundance of the 1987 and 1988 year classes were estimated at 1.8 and 1.2 billion fish respectively, close to the average 1977-91 recruitment of 1.5 billion age-2 fish. The 1989 year class appears to be much weaker (age-2 recruitment was 0.07 billion).

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Dorn. M. W., R D. Methot, E. P. Nunnallee, and M. E. Wilkins. 1990. Status of the coastal Pacific whiting resource in 1990. In Pacific Fishery Management Council Status of the Pacific Coast groundfish fishery through 1990 and recommended acceptable biological catches in 1991, Appendix volume 1. p. A1-A77. Pacific Fishery Management Council, Metro Center, Suite 420, 2000 SW Fit Ave., Portland, OR 97201.

2. SABLEFISH

By Richard D. Methot

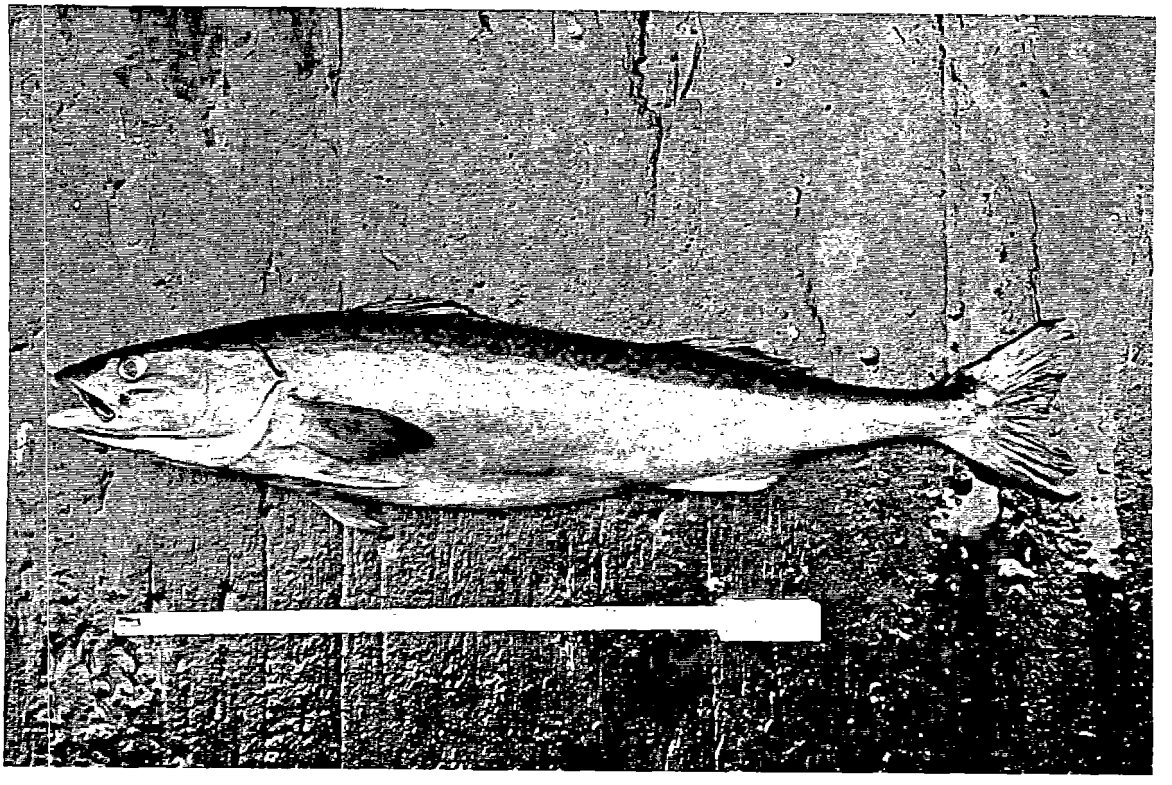


Photo: AFSC

Sablefish *(Anoplopoma fimbria)* occur from Baja California to the Asiatic coast of the Bering Sea Along the West Coast they occur over a wide range of depths. Early juvenile sablefish are neustonic and age-0 fish may school in midwater. By age 1.5 sablefish are primarily demersal and are typically found on the continental shelf in waters less than 200 m deep. Adults are found on the outer shelf and continental slope, especially within and near submarine canyons and gullies. The oldest and largest individuals may be found at abyssal depths. Tagging studies indicate that many sablefish exhibit little alongshore movement, but some may move thousands of miles. Sablefish spawn from November to April, with peak spawning activity occurring in January to February. Sablefish are fast-growing as juveniles, reaching a length of 38 cm by age 1.5 years. Female sablefish mature at a size of about 57 cm (age 5). Mature adults grow little and exhibit great variation in size at age. Sablefish may attain ages of 50+ years and reach sizes of over 100 cm. Adult sablefish tend to eat euphausiids, tunicates, and fish. Sablefish have a long history of harvest by three major gear types: longline, pot, and bottom trawl. The longline fishery began off Washington and Oregon in the 1910s and landings in this area quickly rose to about 1,700 t per year. This longline fishery extended into California beginning in the mid-1920s. The trawl

SABLEFISH
Pacific Coast
COMMERCIAL CATCH (t)

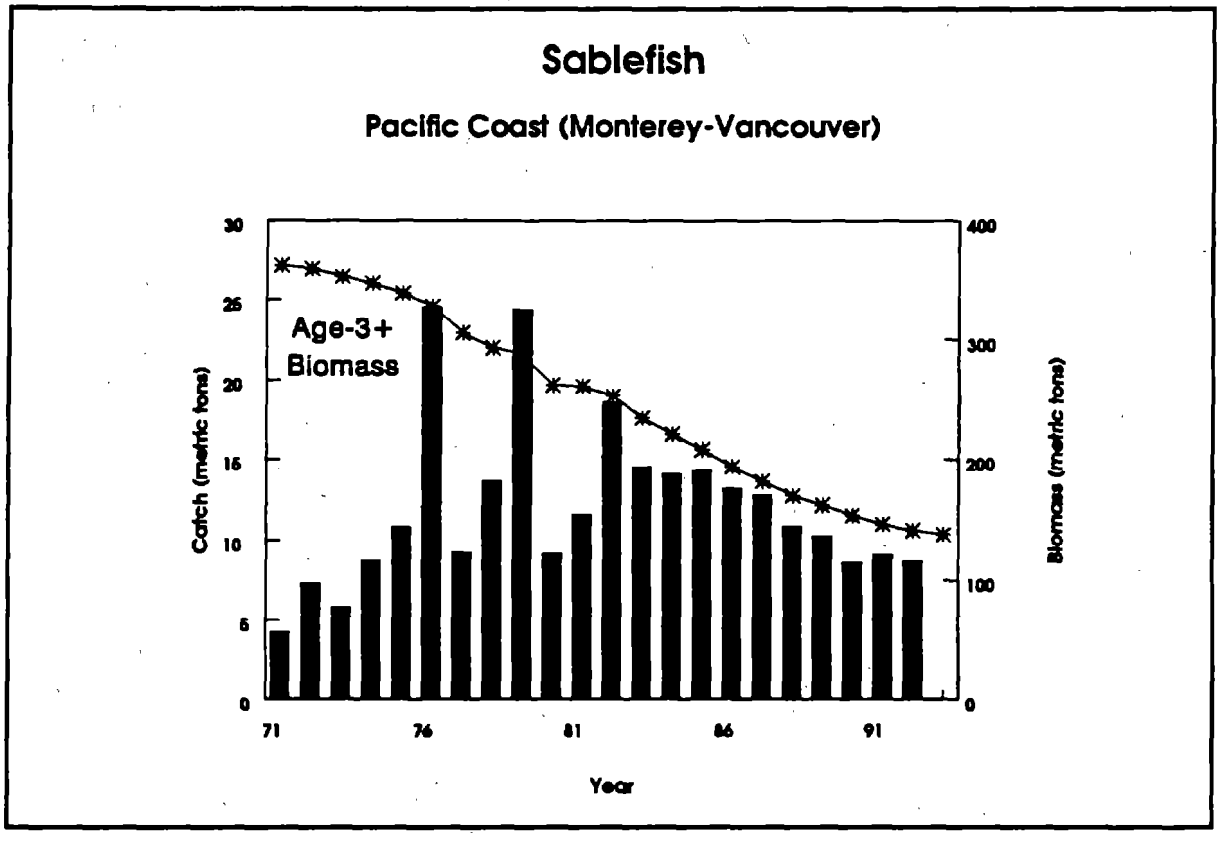
YEAR	Hook-Line	Pot	Trawl	TOTAL
1980	1,661	3,548	3,940	9,149
1981	2,084	3,789	5,681	11,554
1982	1,805	6,419	10,373	18,593
1983	1,338	5,667	7,515	14,521
1984	1,173	3,925	8,975	14,076
1985	2,866	3,799	7,631	14,297
1986	3,792	2,289	7,099	13,179
1987	4,196	1,990	7,577	12,763
1988	3,216	2,046	5,580	10,842
1989	2,574	1,960	5,726	10,260
1990	2,208	1,555	5,270	9,033
1991	3,418	1,073	4,961	9,452
1992	3,093	740	5,438	9,272

March at Amphirite Bank off west Vancouver Island. The diet of Pacific cod consists of small fish (principally sand lance and herring) as well as a wide variety of invertebrates (including euphausiids, shrimps, crabs, and squid).

Pacific cod are at the southern limit of their range off the U.S. West Coast Populations in this area have faster growth rates, mature at a younger age, and have higher natural mortality rates than the more abundant northern stocks. Asymptotic size is approximately 74 cm, and the natural mortality rate lies in the range 0.55-0.63. The stock in this area is more prone to recruitment failure than the northern stocks of Pacific cod, suggesting that the environmental conditions necessary for successful spawning and larval success occur infrequently in this area. Water temperature appears to play a critical role in determining recruitment success. Tagging studies indicate the existence of migratory exchange between stocks in U.S. waters and the stock occurring off the west coast of Vancouver Island in Canada.

Pacific cod are captured primarily by commercial bottom trawls. Commercial-sized aggregations of Pacific cod are found on the spawning grounds in winter and in feeding areas in summer. The fishery in U.S. waters is primarily conducted in summer, with about 75% of the catch landed from April to September. The fishery for cod is opportunistic, since aggregations of Pacific cod occur sporadically in U.S. waters. Lingcod and Pacific cod often occur together in the catch. The recreational fishery is currently small relative to the commercial fishery. The annual ex-vessel value of Pacific cod landings has averaged $1.03 million from 1990 to 1992.

Results of the triennial West Coast trawl survey indicate that Pacific cod biomass in U.S. waters was high in 1977, declined steeply in 1980 and has remained relatively stable since that time. The bulk of the large catches from 1987 to 1989 in U.S. waters was composed of an exceptionally strong 1985 year class that was also present in the west Vancouver Island and Hecate Strait Pacific cod stocks. The current ABC of 3,200 t was set slightly lower than the maximum annual catch in recent years--3,300 t landed in 1988. The management



strategy of allowing a high fishing mortality rate when Pacific cod are present in commercial quantities in U.S. waters is justified by the high natural mortality rate, the rapid growth rate, and the extreme variability of recruitment of Pacific cod in this area

For further information

Westrheim, S. J., and J. V. Tagart. 1984. Bathymetric distribution of Pacific cod *(Gadus macrocephalus)* off British Columbia and Washington State. Int. North Pac. Fish. Comm. Bull. 42:189-199.

SABLEFISH
Pacific Coast

Average catch (1983-92)	= 11,800 t
Long-term potential yield (MSY)	= 6,900 t
Acceptable biological catch (1993)	= 7,000 t
Importance of recreational fishery	= Minor
Management	= Groundfish FMP
Status of exploitation	= Fully exploited
Age at 50% recruitment	= 5 years (males) 5 years (females)
Length at 50% maturity	= 51 cm (males) 57 cm (females)
Assessment approach	= Size and age structured separable analysis
Fishing strategy	= constant 6.8% exploitation
F (1992)	= 7.1% exploitation, ages 2+

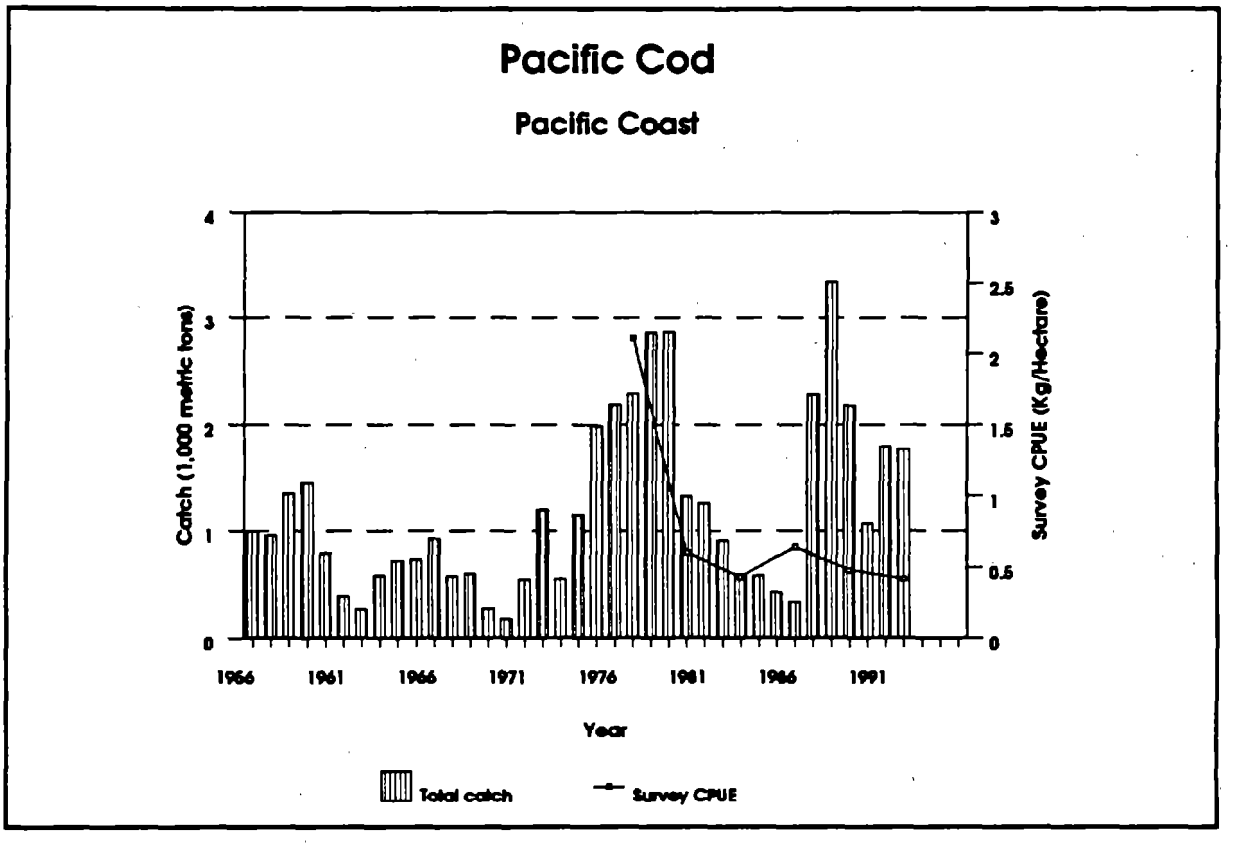
By Martin W. Dorn

The Pacific cod *(Gadus macrocephalus)* is a demersal gadid similar to Atlantic cod in appearance and life history characterstics. Pacific ccxl are distributed in the North Pacific Ocean from central California to the Bering Sea., and south along the Asiatic coast to Japan. Pacific cod are most abundant on the continental shelf between 50 and 200 m. The abundance of the coastal stock declines rapidly south of the U.S.-Canada boundary. spawning of Pacific cod off the west coast of the United States has not been documented, though a small inshore stock regularly spawns off Port Townsend. Washington, in northern Puget Sound Spawning occurs in February-March at Amphirite Bank west Vancouver Island The diet of Pacific cod consists of small fish (principally sand lance and herring) as well as a wide variety of invertebrates (including euphausiids, shrimps, crabs, and squid).

Pacific cod are at the southern limit of their range off the U.S. west coast. Populations in this area have faster growth rates, mature at a younger age, and have higher Mural mortality rates than the more abundant northern stocks. Asymptotic size is approximately 74 cm, and the natural mortality rate lies in the range 0.55-0.63. The stock in this area is more prone to recruitment failure than the northern stocks of Pacific cod suggesting that the environmental conditions necessary for successful spawning and larval success occur infrequently in this area. water temperature appears to play a critical role in determining recruitment success. Tagging studies indicate the existence of

PACIFIC COD
Pacific Coast
CATCH (t)

YEAR	CATCH
1983	697
1984	587
1985	427
1986	334
1987	2,281
1988	3,345
1989	2,183
1990	1,065
1991	1,796
1992	1,775



migratory exchange between stocks in U.S. waters and the stock occurring off the west coast of Vancouver Island in Canada.

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PACIFIC COD
Pacific Coast

Average catch (1980-92)	=	1,449 t
Long-term potential yield (MSY)	=	Unknown
Acceptable biological catch (1993)	=	3,200 t
Importance of Recreational fishery	=	Minor
Management	=	Groundfish FMP
Status of exploitation	=	Possibly fully exploited
Age at 50% recruitment	=	2.5 years (males)
		2.3 years (females)
Length at 50% maturity	=	50 cm (males)
		53 cm (females)
Assessment approach	=	CPUE trend
Fishing strategy	=	Not available
F (1992)	=	Unknown

For further information-

Westrheim, S. J., and J. V. Tagart. 1984. Bathymetric distribution of Pacific cod *(Gadus macrocephalus)* off British Columbia and Washington State. Int. North Pac. Fish. Comm. Bull. 42:189-199.

By Peter B. Adams

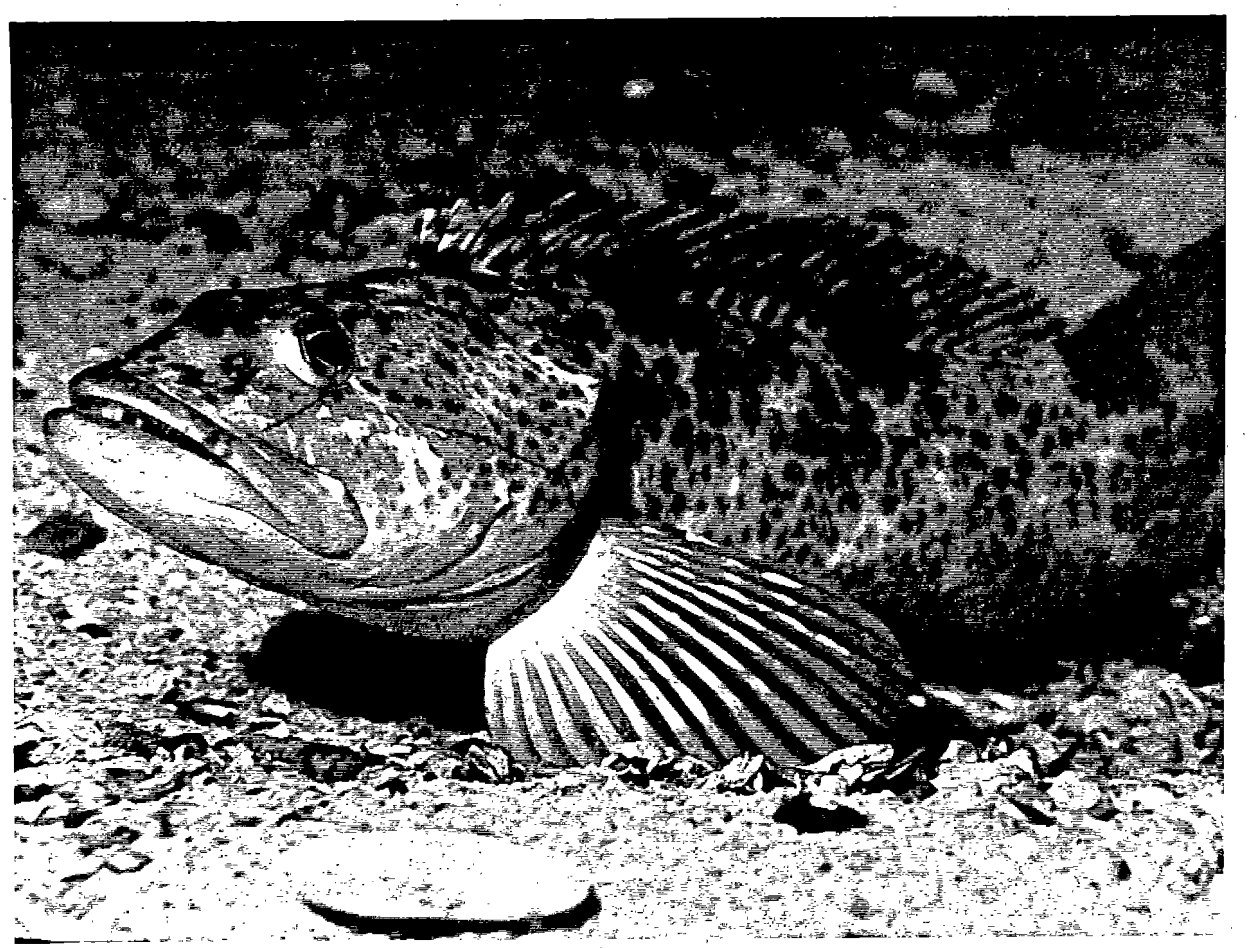


Photo: AFSC

The lingcod *(Ophiodon elongatus)* is a demersal greenling species found in nearshore waters off the west coast of North America from Baja California to the Alaska Peninsula. Their center of abundance is off British Columbia and they are uncommon south of the U.S.-Mexico border. Lingcod are found over a wide range of substrates at depths from 3 to 400 m, but most occur in rocky areas from 10 to 100 m. Canadiantagging studies have shown that adult lingcod exhibit strong home-site fidelity; however, individual fish do make long movements of as much as 690 km. Adult lingcod are piscivorous, feeding on mckfiih (genus *Sebastes),* Pacific whiting, and Pacific herring. Average age of maturity of female lingcod is 4 years or a length of 68 cm and age 2 or a length of 50 cm for males. In U.S. landings, lingcod range in length from 40 to 80 cm and in

LINGCOD
Pacific Coast
COMMERCIAL AND RECREATIONAL CATCHES (t)

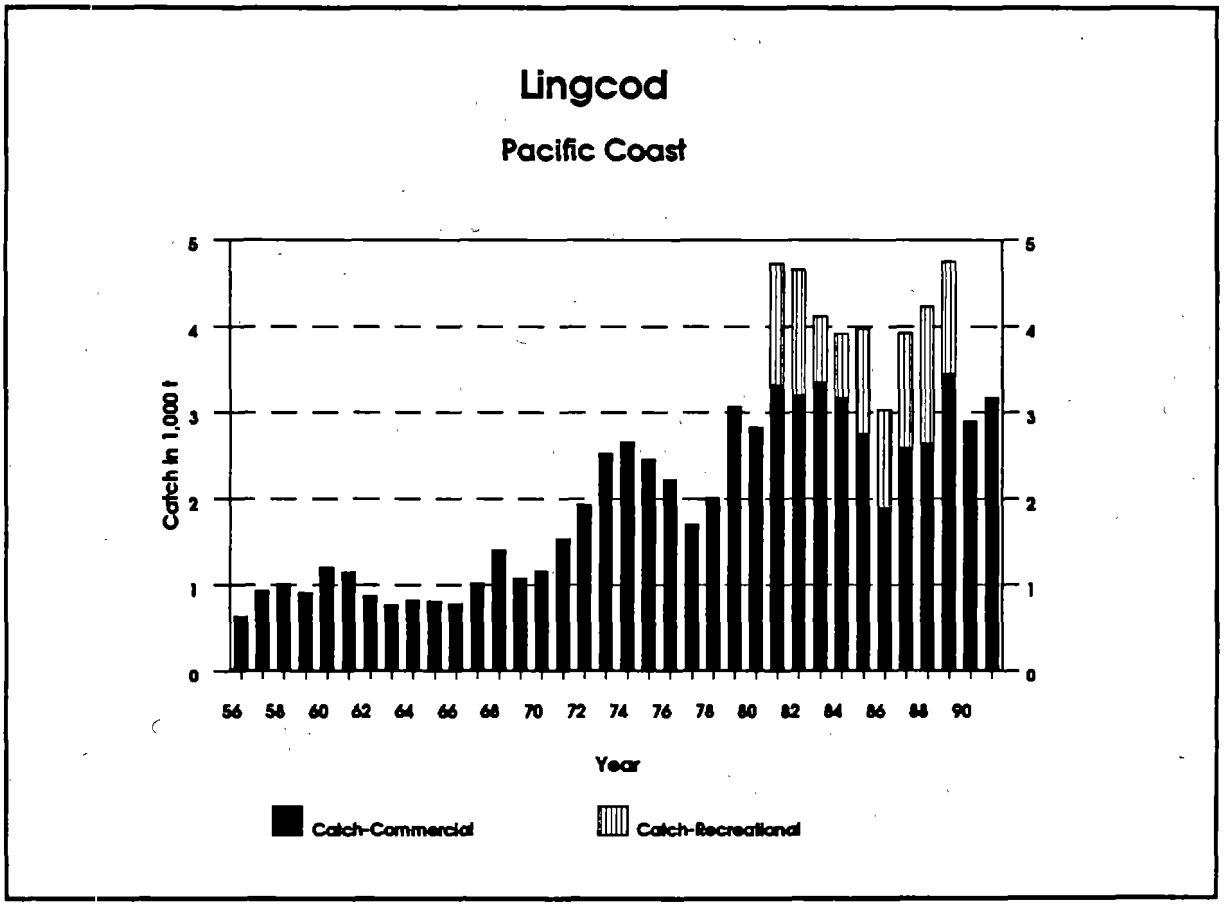
Year	Commercial	Recreational	Total
1982	3,205	1,442	4,647
1983	3,351	768	4,119
1984	3,179	735	3,914
1985	2,752	1,225	3,977
1986	1,884	1,152	3,036
1987	2,585	1,341	3,926
1988	2,636	1,596	4,231
1989	3,447	1,300	4,747
1990	2,896	-	-
1991	3,182	-	-
1992	3,065	-	-

weight from 0.5 to 6.0 kg. The species has a maximum reported length of 150 cm and maximum reported weight of 154 kg.

Lingcod have a unique form of reproduction, which involves territoriality, nests. and a guardian male. Males establish territories in rocky areas in shallow water (low tide line to 30 m) where currents are strong enough to oxygenate the egg mass and prevent death of the embryos. Peak spawning occurs in January and February. A female chooses a male and its nesting site for spawning. In the nest the eggs are cemented to each other within a gelatinous mass. After spawning, the male remains to guard the nest from predation until hatching is complete. The guardian male is very aggressive during this period and is therefore highly susceptible to sport fishing. An unguarded egg mass is invariably eaten by predators. The eggs hatch about 7 weeks after they are spawned. The larvae and juveniles are pelagic until the end of June when the juveniles migrate to benthic habitats.

Commercial lingcod landings from U.S. waters have averaged 2,700 t since 1970, at which time there was a rapid increase from a previous level of around 1,000 t This increase was the result of market demand. Since 1970, landings have had wide fluctuations, probably due to strong and weak year classes moving through the fishery. Commercial landings come predominantly from trawls, averaging 83% of the total landings from 1981 to 1990. However, the nontrawl fishery (70% hook and line in recent years) has increased from 13% of the total landings in 1981 to 21% in 1990. Lingcod landings are largest in Washington and are progressively smaller in Oregon and California. Canadian landings are similar in size to U.S. landings, averaging 2,800 t during the period from 1980 to l985. Thee commercial fishery is managed with an ABC of 7,000 t. There are also restrictions on where gill nets may be used.

The recreational catch is a large component of the total lingcod catch, averaging 1.219 t or 30% of the combined commercial and recreational lingcod catch during the years 1981-89. This is one of the few



West Coast groundfish species with a significant recreational fishery. The recreational fishery is managed with a three (Washington and Oregon)-to-five (California) fish bag limit, and California imposes an additional 56-cm (22-in) minimum size limit.

In 1991, a coastwide lingcod monitoring program to obtain length-frequency and age-structured data was initiated; however, currently there are no mortality estimates on which to base an assessment. While there are areas where lincod are locally depleted (severely in some instances, such as Puget Sound), there is no evidence of overfishing on the overall population.

LINGCOD
Pacific Coast

Average commercial catch (1983-92)	= 2,900 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 7,000 t
Importance of recreational fishery	= 30% of catch
Management	= Groundfish FMP
Status of exploitation	= Unknown
Length at 50% recruitment	= Unknown
Length at 50% maturity	= 68 cm (females) 50 cm (males)
Assessment approach	= Catch landings
Fishing strategy	= $F_{35\%}$ = unknown
F (1991)	= Not available

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5. PACIFIC OCEAN PERCH

By Daniel H. Ito and James N. Ianelli

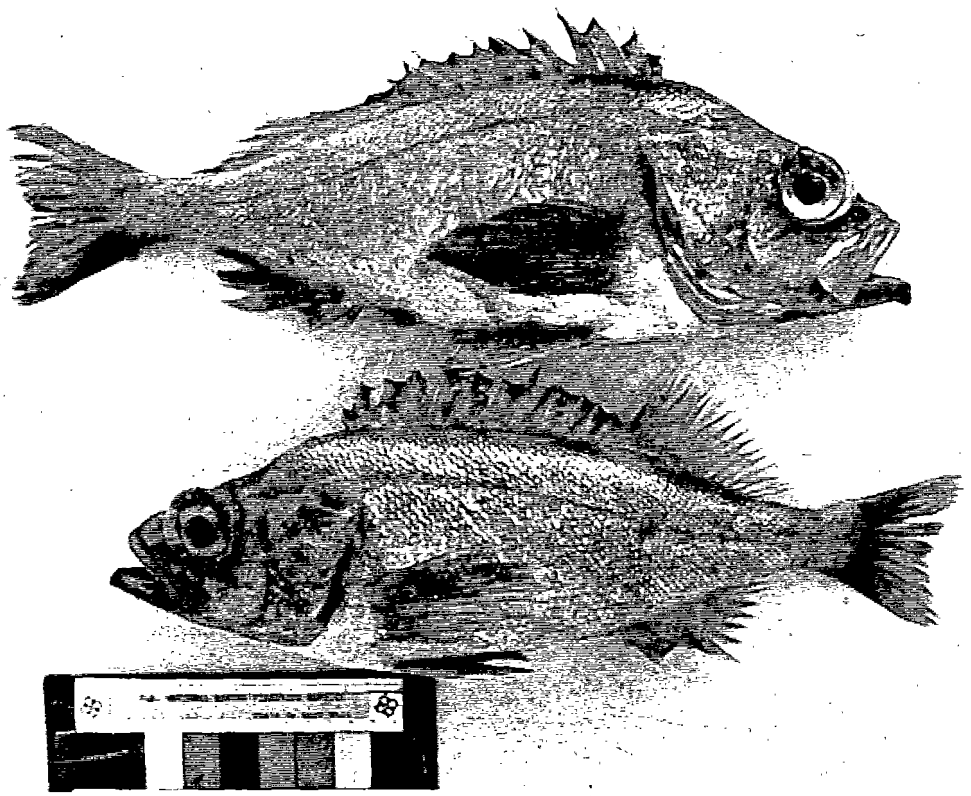

Photo: AFSC

Pacific ocean perch (POP, *Sebastes alutus)* is one of over 65 species in the genus *Sebastes,* commonly referred to as rockfish. Distribution along the North American coast ranges from La Jolla, California, to the western boundary of the Aleutian Archipelago and along the continental slope of the eastern Bering Sea. POP in the Vancouver and Columbia INPFC areas are managed by the Pacific Fishery Management Council (PFMC).

A demersal species, POP are usually associated with rocky substrates found in and-along gullies and submarine depressions of the outer continental shelf and upper slope regions, but hydrographic and biological factors also influence their distribution. Although POP can be found at depths ranging from 50 to 700 m, commercial quantities generally occur between 100 and 400 m. Pacific ocean perch are slow growing and long lived Longevity has been estimated at 90 years, which is consistent with an estimated instantaneous natural mortality rate of 0.05. This species begins to recruit to the fishery at age 5 and is fully recruited by age 10, corresponding with fork lengths of about 26 and 32 cm, respectively. Most of the commercial catch is comprised of individuals ranging from 25 to 50 cm. Females are viviparous, retaining eggs in the ovary after fertilization until yolk sac absorption. Mating takes place in late fall or early winter, with subsequent larval extrusion occuring in late winter or early spring.

Prior to 1965, the POP resource in the Vancouver and Columbia INPFC areas were harvested almost entirely by Canadian and U.S. vessels. The vessels were generally under

PACIFIC OCEAN PERCH
Pacific Coast
COMMERCIAL CATCH (t)

	AREA	
	U.S.	
	Vancouver	Columbia
1983	322	1,205
1984	573	924
1985	420	756
1986	681	714
1987	349	559
1988	122	650
1989	338	1,104
1990	303	675
1991	562	800
1992	520	512

200 gross tons and less than 33 m in length, consequently they had very little at-see processing capabilities. Landings from 1956 to 1964 averaged 2,018 and 1,980 t in the Vancouver and Columbia INPFC areas, respectively.

Catches increased dramatically after 1964 when the Soviet Union and Japan entered the fishery. They employed large factory stem trawlers and operated for extended periods of time. Peak removals by all nations combined amounted to 16,358 t from the Vancouver INPFC area in 1966 and 23,976 t from the Columbia INPFC area in 1967.

Immediately following these peak removals, production declined very rapidly. These harvests appear to have been based on a combination of good recruitment and an accumulation of older fish in the population. By 1969, the Pacific ocean perch stocks were reduced to about 15% of their 1960 biomass. Catches since 1979 have been restricted by the PFMC in an attempt to rebuild the resource. Harvests within the past 10 years (1983-92) have averaged about 420 t in the U.S. portion of the Vancouver INPFC area (U.S.-Vancouver) and 790 t in the Columbia KNF'FC area.

Early trends in the POP stock are indicated by fishery CPUE data. Recent research surveys have been used to provide fishery independent assessments of the abundance, distribution, and biological characteristics of POP. Coastwide trawl surveys were conducted in 1977, 1980, 1983, 1986, and 1989 to assess the major groundfish species. In addition, trawl surveys directed specifically at assessing the POP resource were conducted in 1979 and 1985. Survey estimates of biomass. however, were usually characterized by large variances. Such large variances were probably due to the patchy distribution of this resource. Other factors such as inadequate sampling, inappropriate sampling gear, and fish behavior may have also contributed to the variance.

In 1992 a stock assessment was performed using the stock synthesis model. This method incorporates diverse sources of information on size and age composition of the different fisheries and surveys in addition to data on biomass indices and individual growth. An assessment in 1987 had indicated that the stock remained depleted The new analysis indicated that the stock has increased slightly, but remains at a low level. The 1985 year class is estimated to be as strong as the 1970 year class, so the mature biomass is projected to increase in the short-term.

PACIFIC OCEAN PERCH
Pacific Coast
(Vancouver-Columbia area)

Average catch (1983-92)	= 1,210 t
Long-term potential yield	= 1,700 t
Acceptable biological catch (1993)	= Zero
Importance of recreational fishery	= None
Management	= Groundfish FMP
Status of exploitation	= Overexploited
Length at 50% recruitment	= 32-34 cm
Length at 50% maturity (Females)	= 32.2 cm
	29.4 cm (Males)
Assessment approach	= Stock synthesis
Fishing strategy	= Bycatch only
F(1992)	= < 0.10

The harvest of POP is kept low by imposition of a 3,000 lb limit per trip, but results in an unknown level of discard at sea. The recent assessment evaluated the effect of several different discard rates and concluded that the contribution of discards to overall fishing mortality may compromise rebuilding plans. However, simulation studies indicate that the average rebuilding rate is slow, even at low fishing mortality rates. Given the current condition of the stock, the U.S. West Coast POP stock remains at a bycatch-only level. The triennial trawl survey conducted in 1992 should provide new insights on the condition of the POP stock.

For further information

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6. SHORTBELLY ROCKFISH

By Donald E. Pearson

The shortbelly rockfish *(Sebastes jordani)* is a viviparous, semidemersal species reaching a maximum length of 30-32 cm and maximum weight of 350 g. Shortbelly rockfish get their name from the fact that, unlike other rockfish species, their anal vent is located well forward of their anal fin. Shortbelly rockfish become sexually mature between 2 and 3 years of age. The maximum recorded age for shortbelly rockfish is 32 years, but fish older than 18 years are uncommon. This species has been found from San Benito Island, Baja California, to La Perouse Bank, British Columbia- The highest concentration is thought to occur between Santa Cruz, California, and Bodega Bay, California, with another secondary concentration in California's Channel Islands area. Shortbelly rockfish have been found in depths up to 283 m, with the majority between 90 and 165 m. Euphausiids constitute 99% of their diet. Large schools of shortbelly rockfish are typically found near the edge of the continental shelf over sand and mud substrates. School size is highly variable but can be several kilometers in diameter and quite dense. There is evidence that shortbelly rockfish schools are segregated by age or size, with larger and older fish often found in somewhat deeper water than younger and smaller ones. Research trawls typically have shown that few other species are mixed in with shortbelly rockfish schools.

Spawning occurs from November through May, with peak spawning from January through late March. Females 17 to 30 cm in length would be expected to release from 6,000 to 50,000 larvae. Juveniles are pelagic for approximately 6 months. Juvenile shortbelly rockfish are a major part of the diet of chinook salmon and many species of seabirds.

At present there is no directed commercial or sport fishery for this species due to its small size. However,, the shortbelly rockfish has strong potential as a target for a developing commercial fishery due to its high abundance along some areas of the California coast. The current estimated biomass between Santa Cruz and Bodega Bay, California, is approximately 200,000 t and MSY is in the range 13,400 - 23,500 t. The current potential yield may be about three times the MSY, but there is considerable uncertainty in biomass and MSY levels. The PFMC has adopted an interim coastwide ABC of 58,000 t until further studies are conducted to determine the true potential yield for this species. Both Russia and Japan have recently expressed an interest in harvesting shortbelly rockfish, possibly as a joint venture operation.

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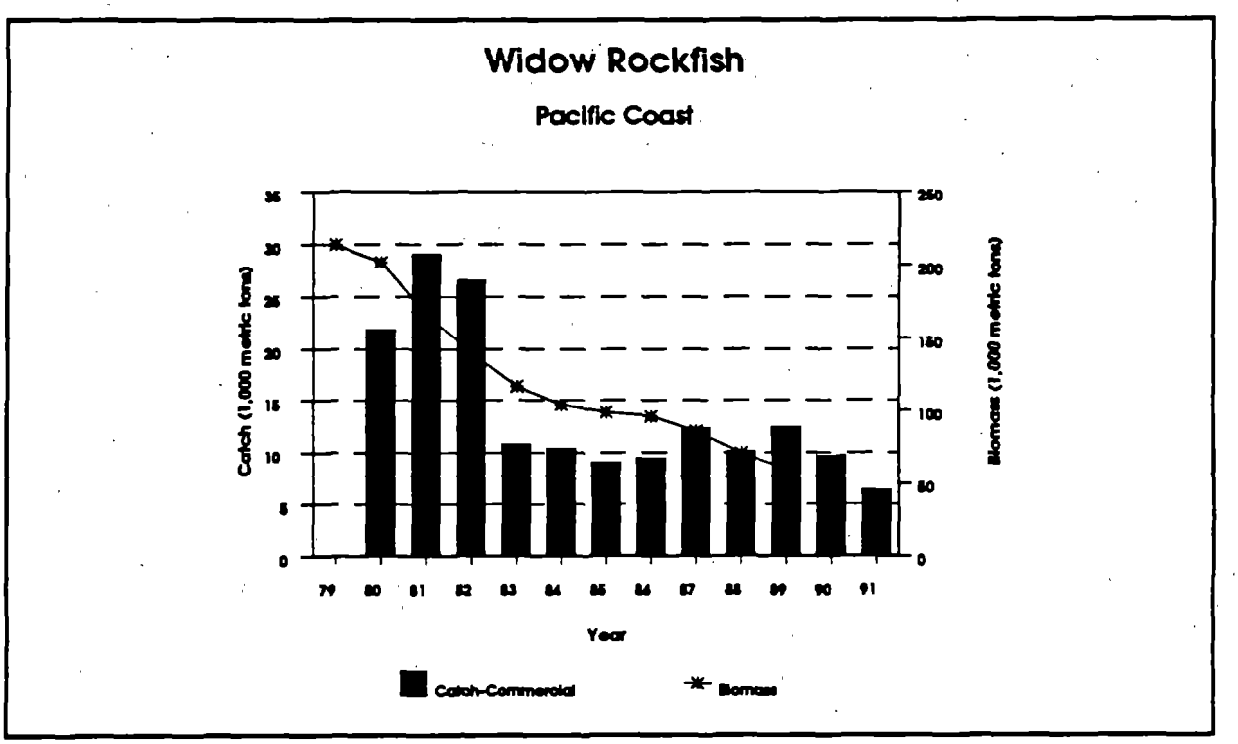
SHORTBELLY ROCKFISH
Pacific Coast

Average catch (1980-90)	= 4 t
Long-term potential yield (MSY)	= 13,400 to 29,000 t
Acceptable biological catch (1993)	= 58,000 t
Importance of recreational fishery	= None
Management	= Groundfish FMP
Status of exploitation	= Unexploited
Length at 50% recruitment	= 20 cm (Females) 20 cm (Males)
Length at 50% maturity	= 16 cm (Females) 16 cm (Males)
Assessment approach	= Yield per recruit
Fishing strategy (F = M)	= 0.20-0.35
F (1990)	= 0

By Jean B. Rogers and Donald E. Pearson

The widow rockfish (Sebastes entomelas) is a viviparous semipelagic species that forms dense, midwater schools. It is distributed from Todos Santos Bay, Baja California, to Kodiak Island, Alaska, but commercial catches come primarily from near the edge of the continental shelf off the coasts of Oregon and southern Washington. Adult widow rockfish inhabit depths of 24-366 m, preferring bottom depths of 140-230 m. Large schools often form at night in midwater, but schooling behavior is dynamic; widow rockfish behavior is probably influenced by food abundance and oceanographic conditions. Adult widow rockfish feed primarily on midwater prey, including euphausiids, sergestids, salps, myctophids, and a variety of small fish. Young fish are pelagic for several months after extrusion by females and during the tatter part of that stage, and they feed on copepods and euphausiids. Life history parameters far widow rockfish vary by latitude. For the area south of latitude 43° N. the asymptotic mean total length is estimated at 41.5 cm for males and 47.6 cm for females, white north of that widow rockfish are larger: 44 cm for males and 50.5 cm for females. About 50% of females off California are mature at age 5 (37 cm); Oregon females are 50% mature later, at age 7 (42 cm). California males are about 50% mature at age 5 (36 cm), while 50% maturity for males off Oregon has been estimated at age 4 (37 cm). Spawning (larval extrusion) off California peaks in January to February and spawning off Oregon peaks in February to March off Oregon. Fecundity off Oregon at 50% maturity is approximately 250,000 eggs, with the maximum fecundity measured at 1.1 million eggs. Maximum fecundity measured off California is 800,000 eggs, with fecundity at 50% maturity about 100,000 eggs. Adults reach a maximum length of 60 cm, and the maximum recorded age for this species is 59 years.

Landings dramatically increased when the directed commercial fishery began, and then declined as the fishery was regulated to meet recommended optimum yields or harvest guidelines. Landings increased from less than 1,200 t in 1978 to more than 29,000 t in 1981, the year with the highest landing. During that time, the widow rockfish became the single most important rockfish species in Washington, Oregon, and California. In late 1982, the PMFC implement&i regulations to protect the stock. Since 1983, trip limit restrictions have kept



landings close to or below the desired catch for the year, which has fluctuated from a maximum of 12,361 t in 1987 to a minimum of 6,367 t in 1991. Recreational landings were not available for 1990 and 1991, and were assumed to be close to those in 1989.

Although the fishery began with vessels using midwater trawl gear, as trip limits have become more restrictive, fishermen have increasingly used bottom n-awls. Oregon. 1991 widow rockfish landings from bottom trawls were close to the amount landed by midwater trawls. Fishermen may be switching to roller gear in an attempt to meet trip limits without excessive discarding; midwater gear is so efficient at catching widow rockfish schools that it is difficult to control the amount of fish caught in a tow. Discards since regulations were insrituted have been estimated to average 16% of the landings. Trip limits have not affected large catches made in 1991 from the Cobb Seamount, which is outside the U.S. EEZ The Cobb Seamount is a pinnacle 18 fathoms deep, located approximately 289 nmi off the northern Oregon coast. Fishermen from Oregon and Washington landed 540 t from that area, which was 9% of the total widow rockfish landings for the year. Fish caught in that area were mostly small, young fish and may comprise a stock separate from the coastal stock Stock assessments for widow rockfish have been based on stock synthesis modeling and cohort analysis, using catch-at-age data obtained from port sampling. Analysis of age composition has shown that annual recruitment rates to the population are highly variable. Strong year classes occurred in 1970-71,1977-78, and 1980-81. Annual biomass estimates consistently declined from 1979 to present, and older fish have gradually disappeared from the landings. Most fish in the landings are now less than 15 years old Recent stock assessments estimatedthat abundance should stabilize at about the current level, with the long-term average yield about equal to the ABC for 1991 (7,000 t.

A stock assessment will be completed in 1993 using the stock synthesismodel. Lack of a reliable survey estimate of abundance has made it difficult to estimate the absolute abundance of the stock in past assessements; therefore, an index using the relative bycatch of widow rockfish in the Pacific whiting fishery will be incorporated into the model

WIDOW ROCKFISH
Pacific Coast
RECREATIONAL AND COMMERCIAL CATCH (t)

YEAR	Rec	Comm
1982	186	26,517
1983	64	10,773
1984	80	10,345
1985	54	9,097
1986	61	9,474
1987	22	12,361
1988	34	10,140
1989	42	12,395
1990	42	9,714
1991	42	6,367

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Hightower, J.E., and W. H. Lenarz. 1990. Status of the widow rockfish fishery in 1990. Appendix F. In Status of the Pacific coast grounfish fishery through 1990 and recommended acceptable biological catches for 1991. Pacific Fishery Management Council, Metro Center, Suite 420, 2000 SW First Ave., Portland, OR 97201.

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WIDOW ROCKFISH
Pacific Coast

Average commercial catch (1983-91)	= 10,077 t
Long-term potential yield (MSY)	= 6,000 - 7,600 t
Acceptable biological catch (1993)	= 7,000 t
Importance of recreational fishery	= Insignificant
Management	= Groundfish FMP
Status of exploitation	= Fully exploited
Length at 50% recruitment	= Females: 35-40 cm Males: 35-40 cm
Length at 50% maturity	= Females: 37 cm Males: 36 cm
Assessment approach	= Stock synthesis, cohort analysis
Fishing strategy	= $F_{35\%}$ = 0.21-0.26
F (1990)	= 0.35-0.72

8. BOCACCIO

By James R. Bence

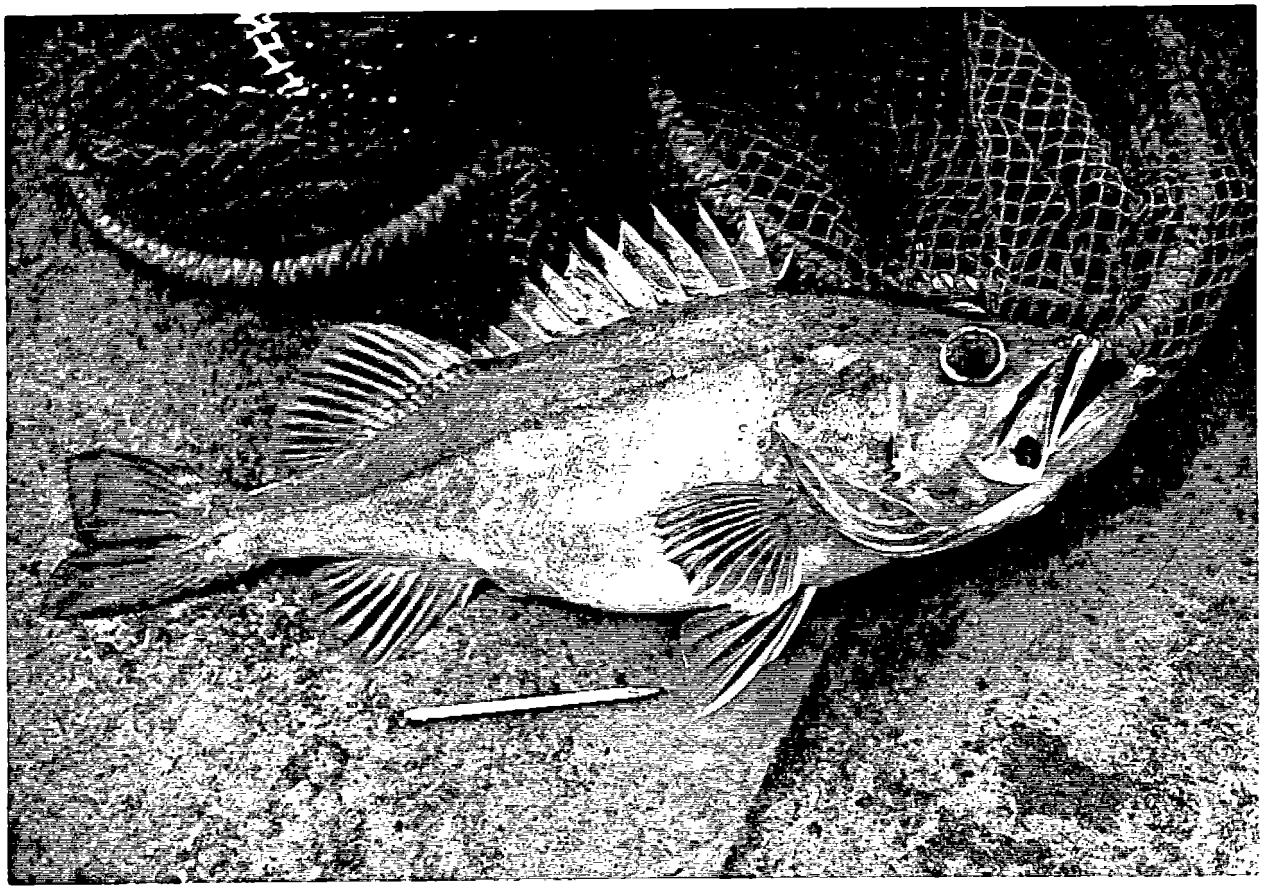


Photo: SWFSC

The bocaccio *(Sebastes paucispinis)* is a substrate-associated viviparous rockfish reaching a maximum length of 90 cm. Among rockfish, bocaccio are noted for their relatively rapid growth, large adult size, and high variation in year-class strength. Some individuals from strong year classes are landed by the trawl fishery at age 1, but full recruitment generally does not occur until age 2 when bocaccio are approximately 40 cm in length. During the past decade, landings have been dominated by the 1977, 1984, and 1988 year classes. As a consequence of the high variability in year-class strength, the size and age structure of the population fluctuates greatly over time. For example, in 1986 most fish landed by the trawl fishery were less than 40 cm in length, while in 1989, the majority exceeded 50 cm; in large part this change reflects the growth of the 1984 year Class.

Although some female bocaccio are sexually mature at 36 cm in length, 50% maturity is reached at 48 cm (age 4). Because fecundity is relatively low for fish smaller than 50 cm, fish below this size contribute relatively little to the total reproductive output of, the population. A 70-cm female can produce more than 1 million planktonic larvae. Larvaeare

BOCACCIO
Pacific Coast
RECREATIONAL AND
COMMERCIAL CATCH (t)

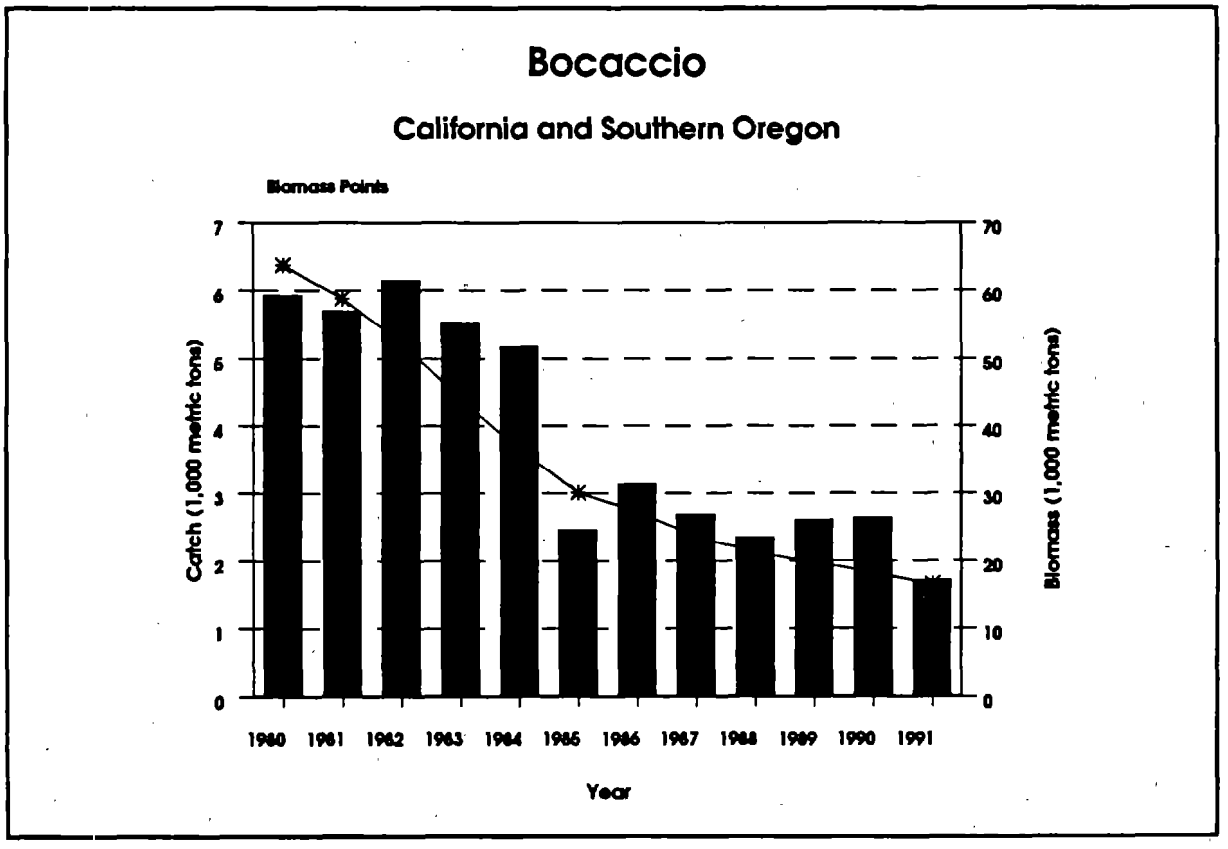
YEAR	Rec	Comm
1982	1,499	5,280
1983	565	5,895
1984	237	5,301
1985	393	2,660
1986	575	2,894
1987	190	2,822
1988	169	2,470
1989	255	2,719
1990	-	2,786
1991	-	2,117

released in the December-May period except off southern California where larvae are released from October-March. Along central California, most larvae that survive to the juvenile stage are born in January and February, but the months of successful reproduction can shift substantially from year to year. Off southern California some females produce two broods in a season, but this appears to be less common to the north. Juveniles remain pelagic for some time and are most common within 30 m of the sea surface, but they move deeper later in the spring, settling to the substrate in late May or early June at lengths of 35-50 mm. Although bocaccio older than 30 years have occasionally been landed in the United States, the bulk of the population is less than 15 years old

Bocaccio are found from central Baja California to Kodiak Island. There appears to be a break in the distribution near Coos Bay in southern Oregon. Adult bocaccio are found from depths of 27-320 m. The bulk of bocaccio landed by the commercial trawl fishery are caught at depths of 110-220 m, and younger and smaller fish are more common in shallower water.

The principal commercial fishing gear used to catch bocaccio is bottom bawl. In recent years, roughly 70% of the landings have been by the trawl fishery, with the line, setnet, and recreational fisheries contributing most of the remainder. Bocaccio from the Mexican border to Coos Bay, Oregon, are managed separately from other species, while bocaccio to the north are included with "other rockfish." Fishing is managed under the Groundfish FMP of the PMFC.

Most landings of bocaccio are made in the southern management area (California and southern Oregon). The trawl fishery is centered near Monterey, California. Nearly all the recreational catches are from California, and non-trawl gear are of lesser (but growing) importance in Oregon and Washington, There are also some uncertainties associated with the, northern landings since estimates of bocaccio landings are not available for all gears and areas. In the southern management area, landings of bocaccio were about 3,000 t annually during the late 1970s, increasing to over 5,000 t by 1981 with the recruitment of the large 1977 year class and have declined to about 2,000 t during the 1985-90 period.



BOCACCIO
Pacific Coast

Average catch (1982-91): U.S. waters	= 3,700 t
California & S. Oregon	= 3,200 t
Long-term potential yield (MSY)	
California & S. Oregon	= 1,680-1,860 t
Acceptable biological catch (1993)	
California & S. Oregon	= 1,540 t
Importance of recreational fishery	= Important in California
Management	= Groundfish FMP
Status of exploitation	= Fully exploited in California and S. Oregon
Length at 50% recruitment	= 39 cm (trawl)
Length at 50% maturity	= 48 cm (females); 42 cm (males)
Assessment approach	= Stock synthesis model
Fishing strategy	= $F_{35\%}$ = 0.105
F (1991)	= 0.1

Recreational survey data, port-sampling datafromthe commercial fishery. and data from a triennial trawl survey were used to assess the stock in the southern area Both recreational and trawl survey indices of abundance indicate a decline in stock biomass over the past decade,dueatleastin part to poor recruitment over this period. The most recent assessment (1992) indicates that biomass declined from about 65,000 t in 1980 to between 13,000 and 22,000 t in 1990. For 1993, spawning stock was projected to be 22% to 2.8% of the average unfished level, but did not appear to be declining rapidly. The 1992 assessment used updated landings that included more components of the bocaccio fishery and provided a more optimistic scenario than the prior (1990) assessment, The ABC for the Califomia-southern Oregon region was reduced from 6,100 t to 800 t for the 1991 season and was increased to 1,540 t for 1993. Landings are controlled by trip limits applied to the rockfish assemblage as a whole and to bocaccio individualy. Trip &nits were first specifically applied to bocaccio in 1991, and this led to a substantial reduction in landings.

The recovery of bocaccio south of Coos Bay, Oregon, depends on the occurrence of one or more strong year classes. Although the 1988 year class is relatively strong, it does not appear to be the equal of the 1977 and 1984 year classes. Furthermore, fish in the 1988 year class had just begun to contribute significantly to the spawning capacity of the stock at the time of the last stock assessment

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9. CANARY ROCKFISH

By Donald E. Pearson and Joseph E. Hightower

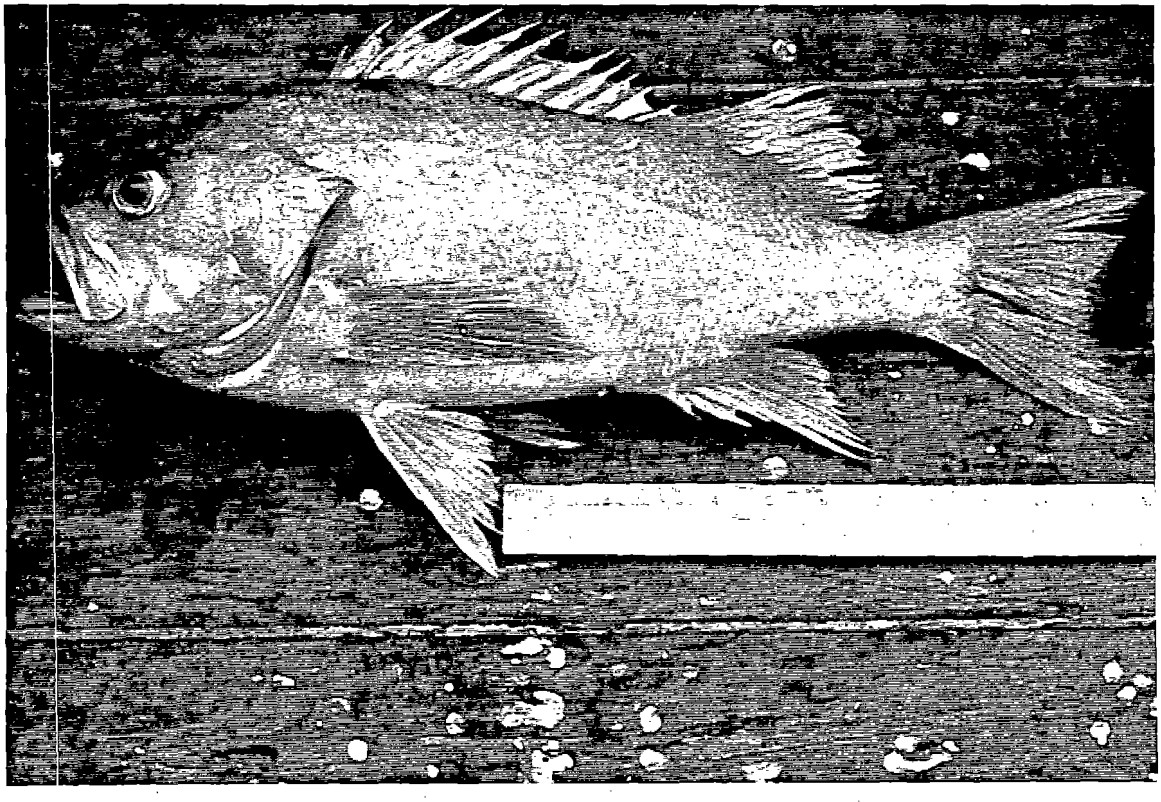

Photo: AFSC

The canary rockfish *(Sebastes pinniger)* is a viviparous, demersal rockfish. Immature fish are often found in nearshore rocky reefs while older, mature adults inhabit offshore rocky reefs. Canary rockfish reach a maximum length of 75-80 cm and weights up to 7.3 kg. Average length in commercial landings is between 50 and 55 cm with average weights of 1.9-2.5 kg. Male and female canary rockfish grow at different rates, with males typically smaller at age than females. In recent years, the average length and age has been declining in commercial landings. Canary rockfish are mature at ages 7 to 9 and have a maximum reported age of 78 years. Male canary rockfish tend to have greater longevity than females, possibly due to the higher natural mortality of older females. Canary rockfish inhabit depths up to 275 m but are fished commercially in depths of 90-180 m. This species is distributed from Cape Colnett. Baja California, to Cape San Bertolome, Alaska. The major concentration of canary rockfish is found between northern Oregon and British Columbia. There is no apparent difference in length at age between fish in the north and those in the south. Canary rockfish feed primarily on euphausiids; however, decapods, squid, herring, and a variety of other fish and macroplankton are also consumed. Spawning occurs between November and April, with peak spawning from December through Januarv. A 50-cm female will release approximately 800,000 larvae while a 60-cm female will release approximately 1.4 million larvae. The juveniles are pelagicforseveral months and then settle to the bottom.

CANARY ROCKFISH
Pacific Coast
RECREATIONAL AND
COMMERCIAL CATCH (t)

YEAR	Rec	Comm
1982	316	4,296
1983	113	4,197
1984	129	1,991
1985	229	2,211
1986	249	1,892
1987	271	2,675
1988	255	1,840
1989	154	2,168
1990	-	1,876
1991	-	2,847

Recreational landings are between 3 and 10% of total commercial landings with the majority of sport-caught canary rockfish being taken in California. In California commercial landings, most canary rockfish are caught by longline gear; while in Oregon (the center of the fishery), the majority are caught by bottom trawls. From 1942 through 1947, a large fishery existed in the Columbia INPFC area to supply the military. During this fishery, an average of 4,248 t per year was landed. Columbia INPFC area landings averaged 4,004 t per year from 1947 through 1966 and 2,326 t per year from 1966 to 1989. Canary rockfish are regulated as part of the *Sebastes* complex under the Groundfish FMP of the PFMC. Trip limits are placed on landings of this complex; however, there are no specific landing limits for canary rockfish. In 1982 (the year with the highest landings since 1967), canary rockfish constituted 4% of the total West Coast groundfish landings; by 1989, they constituted only 2%.

Stock assessments for canary rockfish have been based on catch-and-age composition data obtained from port sampling. NMFS trawl survey data, and logbook data on commercial trawl effort The results suggest that equilibrium recruitment within the Columbia INPFC area is 1.25 to 1.75 million age-3 recruits. That level of recruitment results in an estimated virgin biomass of 34,000-43,000 t and a biomass in 1989 of 8,000-16,000 t. The estimated female spawning biomass in 1989 was between 16 and 33% of virgin levels. The 1991 ABC for the Vancouver, Columbia, and Eureka INPFC areas (2900 t) was about 20% greater than the average landings from 1966 to 1991; thus, the *Sebastes* complex trip limits appear to prevent-landings of canary rockfish from exceeding desired levels.

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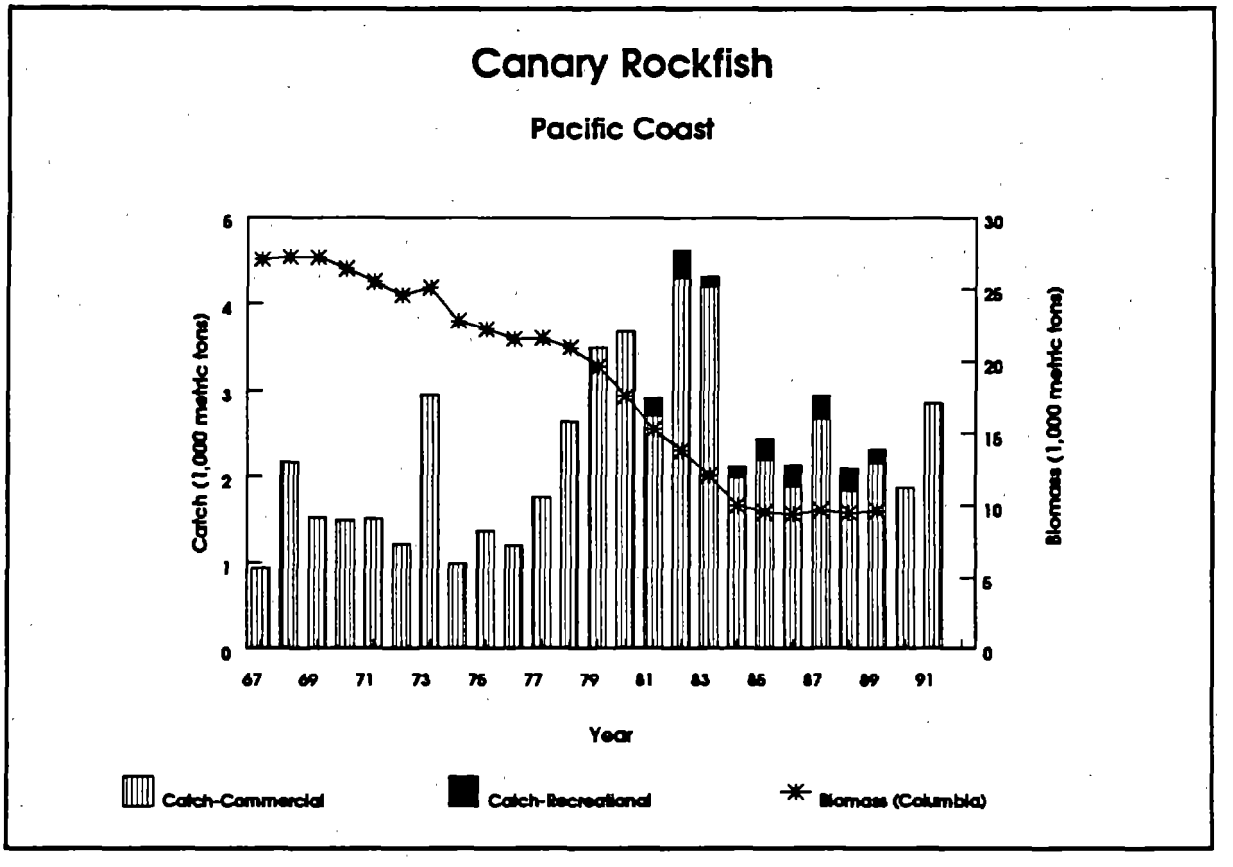

Appendix H. In Status of the Pacific coast groundfish fishery through 1990 and recommended acceptable biological catches for 1991. Pacific Fishery Management Council, Metro Center, Suite 420, 2000 SW First Ave., Portland, OR 97201.

CANARY ROCKFISH
Pacific Coast

Average commercial catch (1983-91)	= 2,410 t
Long-term potential yield (MSY) (Columbia area only)	= 1,190-1,740 t
Acceptable biological catch (1993) (Vancouver-Columbia-Eureka areas only)	= 2,900 t
Importance of recreational fishery	= Important in California
Management	= Groundfish FMP
Status of exploitation	= Fully exploited
Length at 50% recruitment	= Females: 50 cm Males: 41 cm
Length at 50% maturity	= Females: 50 cm Males: 41 cm
Assessment approach	= Stock synthesis, yield per recruit
Fishing strategy	= $F_{35\%}$ = 0.135 to 0.190
F (1989)	= 0.143 - 0.370

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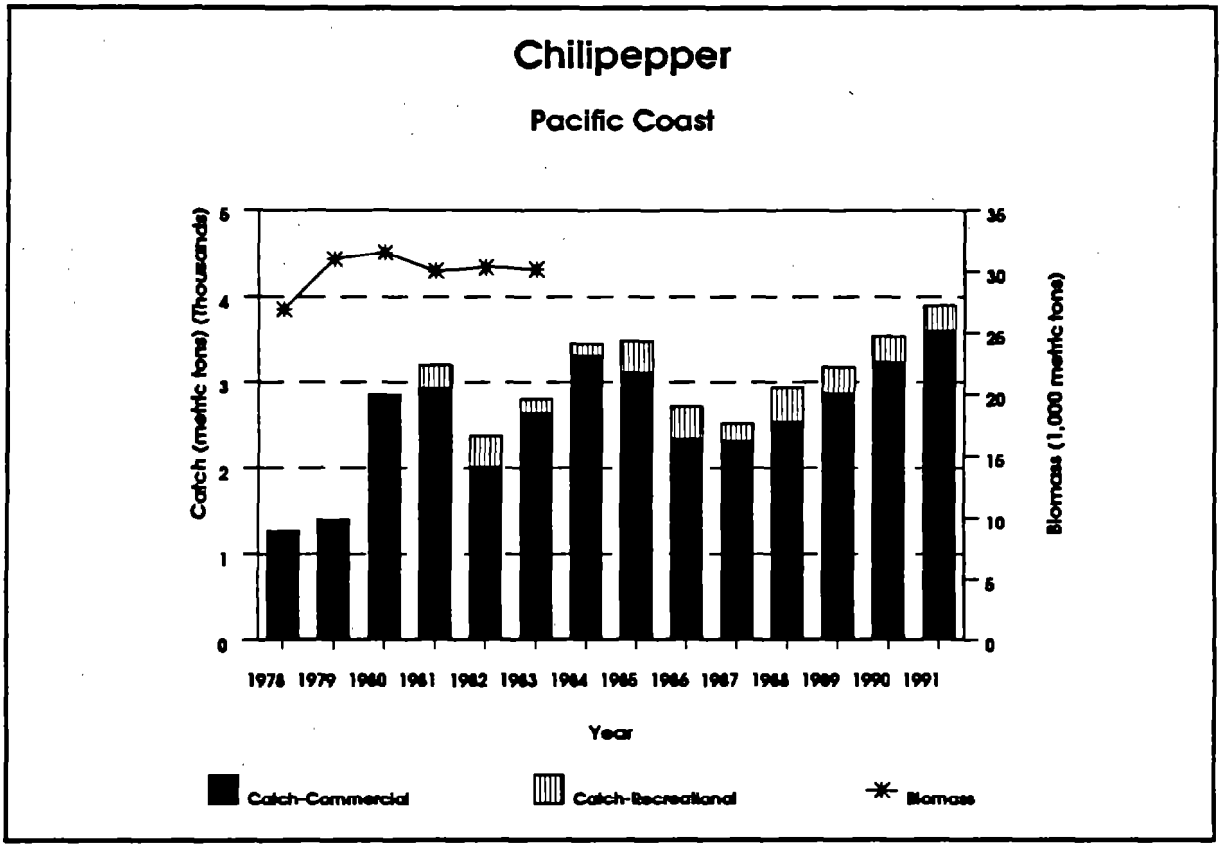
By Jean B. Rogers and Donald E. Pearson

The chilipepper *(Sebastes goodei)* is a southern-latitude, medium-depth member of the rockfish genus. It occurs from Queen Charlotte Sound, British Columbia, to Magdalena Bay, Baja California, but is most abundant off the coast of central Califomia. Adults are found in depths up to 330 m and prefer depths 150-240 m. They are found on deep rocky reefs, as well as on sand and mud substrates and are known also to school in midwater. Adult chilipepper feed on euphausiids, small squid, and small fishes such as lantern fish, anchovy, and juvenile Pacific whiting. Young chilipepper are pelagic for up to several months after extrusion by the females. During the latter part of that pelagic stage, they feed primarily on copepods.

Compared to many of the commercially important rockfish species, chilipepper are short-lived, exhibit substantial difference in growth between males and females, mature at a young age, and have relatively few young. The maximum age is approximately 35 years; most chilipepper in the trawl landings are less than 15 years. Asymptotic mean total length at age is estimated at 39 cm for males and 52 cm for females. Maximum total length measured is 55 cm for males and 59 cm for females. Both males and females begin to mature at age 2, with 50% mature by age 3-4 (males 28-31 cm, females 30-34 cm). Chilipepper are viviparous and extrude larvae from November to April (primarily December to February) andmayhavetwobmodsperseason. Themaximum measured fecundity is 0.5 million eggs; fecundity at 50% maturity is about 10% of maximum.

Estimated total landings of chilipepper have exhibited somewhat cyclical behavior but have increased steadily since 1987. Commercial landings dominate, and a high percent of those come from catches made with bottom trawl gear. Since 1984, however, the combined landings from hook and setnet gear have been substantial (20-50% of the commercial landings). The increase in the commercial landings from 1990 to 1991 resulted from estimated rises in hook fishery landings and bycatch from the Pacific whiting midwater trawl fishery; landings from the bottom trawl fishery decreased.



Information on recreational landings from 1990 and 1991 was not available; it was assumed that they were similar to the 1989 landings.

There is evidence that a strong 1984 year class has sustained the fishery since 1987. Chilipepper typically start to recruit to the trawl fishery at age 3, and age and length frequencies of the landings can vary dramatically with changes in year-class strength. The 1987 trawl landings were dominated by 3 year-olds (about 40% of male landings and 60% of female landings), and the influence of that year class was evident in the subsequent age and length frequencies. The last strong year class was in 1975; from 1980 to 1986 less than 10% of the landings were 3-year-olds. Both trawl survey and recreational CPUE estimates indicate that the chilipepper stock has not declined since 1980.

The commercial Landings have a higher percentage of females by weight than males, probably because females reach a much larger size than males. Females have contributed 60% of the trawl landings since 1986 and up to 80% in earlier years when the females in the catch were larger (primarily 40-50 cm total length). The hook and setnet fisheries tend to catch larger fish than the trawl fishery, and females account for 80-95% of the catches.

In recent years, the chilipepper has become increasingly important in California landings. The chilipepper is frequently caught with bocaccio, a historically important commercial species in California Bocaccio e&mated abundance has declined since 1980, and chilipepper landings have surpassed bocaccio landings in California since 1987. An individual trip limit was placed on bocaccio in 1991, but chilipepper is regulated only as part of a general rockfish complex trip limit

A quantitative stock assessment will be completed in 1993. The stock synthesis model will be used with data from the four fisheries and two indices of abundance. The last quantitative assessment, using catch-at-age analysis, was completed in 1986 and is the basis of the present ABC of 3,600 t.

CHILIPEPPER
Pacific Coast
RECREATIONAL AND COMMERCIAL CATCH (t)

YEAR	Rec	Comm
1982	392	2,005
1983	163	2,640
1984	157	3,302
1985	391	3,111
1986	392	2,334
1987	206	2,315
1988	415	2,530
1989	308	2,864
1990	308	3,232
1991	308	3,597

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CHILIPEPPER
Pacific Coast

Average commercial catch (1983-91)	= 2,880 t
Long-term potential yield (MSY)	= 3,600 t
Acceptable biological catch (1993)	= 3,600 t
Importance of recreational fishery	= Important in California
Management	= Groundfish FMP
Status of exploitation	= Fully exploited
Length at 50% recruitment	= Females: 43-45 cm Males: unknown
Length at 50% maturity	= Females: 30-34 cm Males: 28-31 cm
Assessment approach	= Catch-at-age analysis
Fishing strategy	= $F_{(MSY)}$ = 0.5 - 0.6
F (1983)	= 0.09 - 0.21

11. THORNYHEADS

By Larry D. Jacobson

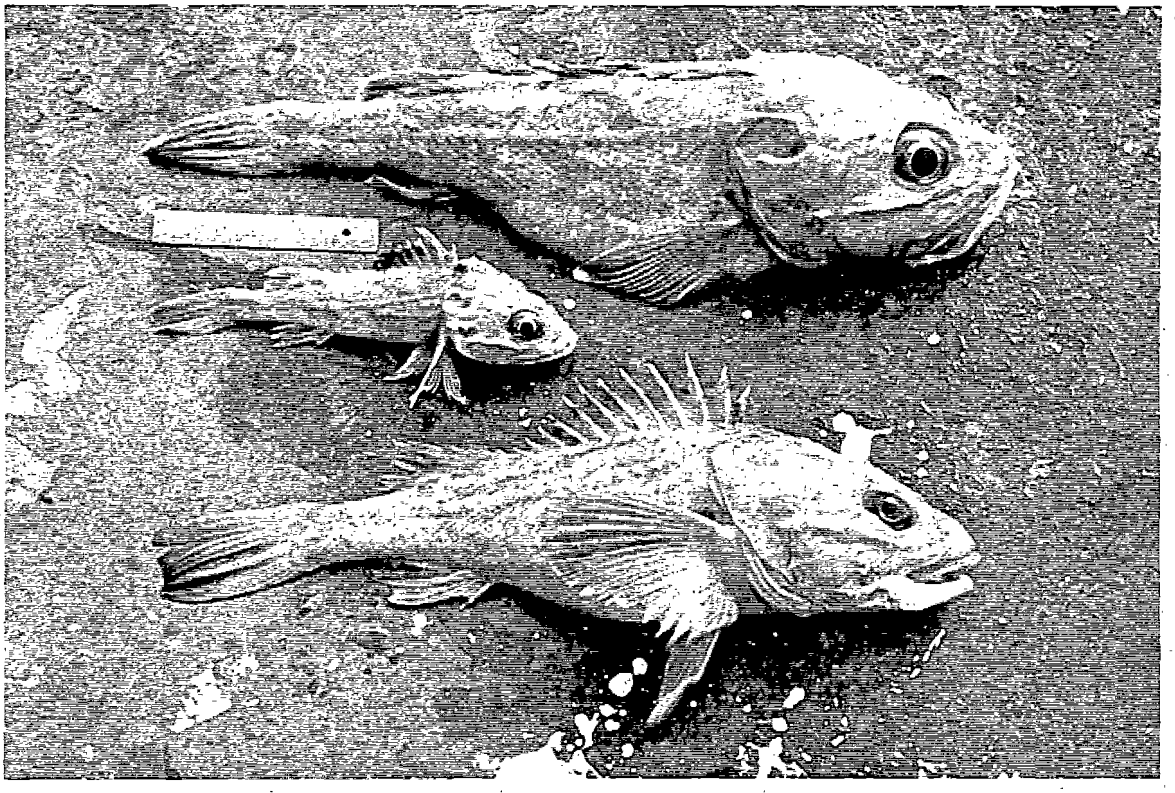

Photo: AFSC

Longspine thornyheads *(Sebastolobus altivelis)* and shortspine thornyheads *(S. alascanus)* are similar in appearance, have overlapping habitats, and are not distinguished in commercial markets although there are differences in important biological characteristics such as growth and mortality.

Longspine thornyheads range from the southern tip of Baja California, Mexico, to the Aleutian Islands while shortspine thornyheads range from northern Baja California to the Bering Sea and the Commander Islands off the Asiatic mainland Both species are demersal and found in relatively deep water primarily on the continental slope. Longspine thomyheads are found off California, Oregon, and Washington at depths that range from 300 to more than 1,500 m, with the bulk of the population occurring between 500 and 1,100 m. Shortspine thornyheads have a slightly broader depth range and are found off California, Oregon, and Washington from about 90 m to more than 1,500 m, with the bulk of the population occurring between 300 and 1,100 m. The upper depth limit for shortspine thornyheads increases toward the northern end of its distribution in Alaska to depths as shallow as 25 m. Large shortspine thomyheads tend to be found in deeper water than small shortspine thornyheads. There is no relationship between depth and length for longspine thornyheads.

Longspine thomyheadsmature at smaller sizes and younger ages than shortspine thornyheads. Fifty percent of female longspine thornyheads are sexually mature at about 19 cm total length (TL) and 14 years of age while 50% of shortspine thomyheads are mature at about 21 cm TL and 12-13 years of age.

Both longspine and shortspine thornyheads spawn buoyant masses of eggs during the late winter and early spring that resemble bilobate "balloons" which float to the surface. Juvenile longspine thornyheads have a pelagic period of about 18-20 months and settle out at about 40 to 60 mm TL. In contrast, juvenile shortspine thornyheads settle in shallower water at smaller sizes (22 to 27 mm TL) and have a

shorter pelagic period (about 14-15 months).

In the context of fishery management, differences in growth rate, maximum size. and longevity between longspine and shortspine thorny heads are most important. Longspine rhomyiheads may Jive between 40 and 50 years and grow to about 35 cm in length while shortspine thornyheads may live well in excess of 100 years and grow to about 75 cm.

Thornyhead landings off Washington, Oregon, and California have increased fivefold since 1981 in response to developing Japanese export markets, higher ex-vessel prices and movement of the bottom trawl fishery into deep waters The bulk of thornyheads landed each year are taken off northern California and Oregon. Shortspine thornyheads predominated in landings prior to 1990, but the proportion of longspine thornyheads in landings has increased during recent years, exceeding 50% in 1990. Ex-vessel prices for thornyheads (adjusted for inflation and measured in 1989 dollars) rose from $0.17 per pound in 1981 to $0.40 per pound in 1990 while revenues (the product of ex-vessel prices and bandings) from the fishery rose from $663,000 to $8.43 million.

Thornyhead landings increased as a proportion of total landings for the deep-water complex (sablefish, Dover sole, and thornyheads), from about 6% in 1981 to about 19% in 1991. During the same period thornyhead revenues increased from abut 5% of total revenues for the deep-water complex to 20%.

Current (1990) coastwide biomass of longspine and shortspine thornyheads is estimated from research surveys to be between 53,000 and 235,000 t There is insufficient information available to determine if abundance has changed in recent years. Port samples indicate that mean lengths of longspine thorny heads taken off northern California have declined since the early 1980s. Catch-rate data for thornyheads from logbooks have proven to be difficult to interpret. primarily because of problems in separating catch rates for the two species and changes in the depth of fishing. Age composition data are not available for either longspine or shortspine thornyheads.

Acceptable biological catch for groundfish managed by the PFMC is based on an $F_{0.35}$ target fishing mortality rate that results in a level of spawner biomass per recruit that is 35% of that in the absence of fishing. Current estimates of $F_{0.35}$ for longspine thornyhead range from 0.15 to 0.33 per year and 0.02 to 0.05 per year for shortspine thornyhead.

Processors are currently reluctant to buy thornyheads smaller than 25.4 cm (10 in) TL. Under current mesh size regulations (11.43 cm [4.5 in] minimum mesh size for codends in bottom trawls), substantial numbers of longspine thornyheads less than 25.4 cm TL are taken when fishing mortality rates are in the range of $F_{0.35}$. Shortspine thornyheads are not subject to this problem. Recognizing the potential waste from discard of small longspine thornyheads under the $F_{0.35}$ harvest policy, target fishing mortality rates that maximize revenue per recruit (F_{maxS} have been calculated. For longspine thornyheads, estimates of F_{maxS} (0.06 to 0.07 per year) are much smaller than estimates of $F_{0.35}$ (0.11 to 00.18 per year)and are similar to estimates of $F_{0.35}$ for shortspine thornyheads (0.02 to 0.05 per year). In contrast, estimates of $F_{0.35}$ (0.021 to 0.050 per year) and F_{maxS} (0.030 to 0.072 per year) for shortspine thornyheads are similar.

THORNYHEADS
Pacific Coast

Average commercial catch (1982-91):	
Shortspine	= 3,047 t
Longspine	= 1,835 t
Thornyhead market category	= 4,882 t
Commercial catch in 1992	= 8,605 t
Monterey-Eureka-Columbia area only:	
Commercial catch in 1992	= 6,959 t
Long-term potential yield (MSY)	= 5,100 - 12,000 t
Acceptable biological catch (1993)	= 7,000 t
Importance of recreational fishery	= none
Management	= Groundfish FMP
Status of exploitation	= Fully exploited
Age at 50% recruitment (bottom trawls):	
Shortspine	= 19 yrs
Longspine	= 16 yrs
Age at 50% maturity (both species)	= 13-14 yrs
Assessment approach	= Spawning biomass per recruit and survey biomass estimates
Management strategy	= $F_{0.35}$
F (1990)	= ≥0.04

Current management advice is that $F_{0.35}$ for shortspine thomyheads be used to set ABC levels for the entire thornyhead market category. The rationale for this advice is that 1) separate ABCs for longspine and shortspine thornyheads would be impossible since fishermen cannot harvest either longspine or shortspine thomyheads exclusively; 2) the two species are difficult to separate in landings; 3) spawning biomass per recruit far both species will meet or exceed the $F_{0.35}$ target levels; and 4) revenue per recruit for both species will be near maximum values as long as the 25.4-cm (lo-inch) minimum size limit continues.

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12. YELLOWTAIL ROCKFISH

By Donald E. Pearson

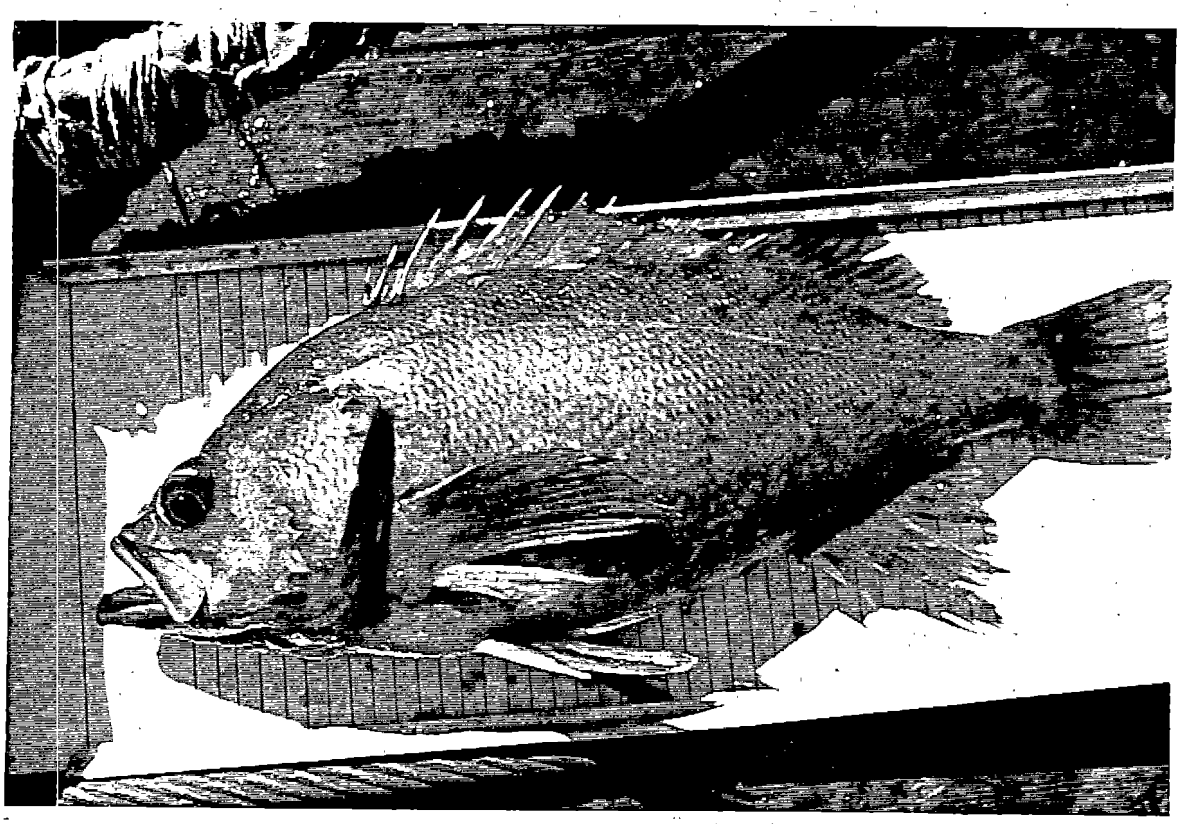

Photo: AFSC

Yellowtail rockfish *(Sebastes flavidus)* is a viviparous, semipelagic species typically inhabiting offshore rocky reefs. Yellowtail rockfish reaches a maximum length of 60-65 cm and weights up to 3.9 kg. Average lengths in commercial landings range between 46 and 52 cm, with average weights of 2.4-3.2 kg. Male and female yellowtail rockfish grow at different rates, with males typically smaller at a given age than females. In recent years, the average length has been declining in commercial landings. Yellowtail rockfish mature sexually at age 6-7 and have a maximum reported age of 64 years. Yellowtail rockfish inhabit depths up to 550 m but are not. common at depths exceeding 190 m. This species is distributed from San Diego, California, to Admiralty Island, Alaska. The major concentration of yellowtail rockfish is found between northern Oregon and British Columbia. In the northern part of their commercial range, yellowtail rockfish grow faster,. reach a greater maximum length, and spawn later than those to the south. Tagging studies have shown that most yellowtail rockfish do not migrate after reaching adult size. They feed on a wide variety of prey including euphausiids, decapods, squid,. herring, smelt, and myctophids.

Spawning occurs between November and June with peak spawning from February through April. A 35-cm female-will release approximately 90,000 larvae while a 55-cm female will release approximately 1 million larvae. Juveniles are pelagic for several months, settle to the bottom, and eventually make their way to offshore rocky reefs.

Recreational landings are 3- 15% of total commercial landings with the majority of sport-caught yellowtail rockfish taken off California In commercial landings, most yellowtail rockfish are caught by bottom and midwater trawl nets; however, hook and line, gill nets. and longline gear also contribute to the landings. Commercial landings increased from about 1,000-2,000 t in the late 1960s to nearly 10,000 t in the early 1980s. Since 1982, the commercial fishery has been regulated by the Groundfiih FMP of the PFMC. The first regulations specifically -limiting the catch of yellowtail rockfish were enacted

in 1985. Since that rime, additional, more restrictive regularions have been instituted to protect the stock, and annual landings have been about 5,000 t per year. In 1983, yellowtail rockfish constituted 9% of the total West Coast groundfish landings; in 1991, they constituted only 4%.

Stock assessments for yellowtail rockfish have been based on catch- and age-composition data obtained from port sampling and from NMFS trawl surveys. Analyses for three Pacific coast stocks suggest that there has been significant exploitation over the past 15 years with resultant declines in abundance. Total biomass from northern Califomia to southwest Vancouver Island, Canada, is estimated to have declined from about 136,000 t in 1967 to about 58,000 t in 1990. Total abundance of two of the three stocks is estimated to be below the optimal level. Fishing mortality rates implemented by the PFMC for those two areas are less than recent levels and some rebuilding is expected ova the next few year.

YELLOWTAIL ROCKFISH
Pacific Coast
RECREATIONAL AND COMMERCIAL CATCH (t)

YEAR	Rec	Comm
1980	-	8,759
1981	466	8,385
1982	1,217	8,718
1983	572	8,224
1984	392	5,299
1985	440	3,264
1986	297	4,148
1987	271	3,971
1988	226	4,966
1989	351	4,233
1990	-	3,689
1991	-	3,614
1992	-	6,029

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YELLOWTAIL ROCKFISH
Pacific Coast

Average commercial catch (1983-92)	= 5,522 t
Long-term potential yield (MSY)	= 6,006-6,823 t*
Acceptable biological catch (1993)	= 4,700 t
Importance of recreational fishery	= Important in California
Management	= Pacific groundfish FMP
Status of exploitation	= Fully exploited
Length at 50% recruitment	= Females: 37-43 cm Males: 37-41 cm
Length at 50% maturity	= Females: 39 cm Males: 38 cm
Assessment approach	= Stock synthesis, cohort analysis, yield per recruit
Fishing strategy	= $F_{35\%}$ = 0.18 - 0.25
F (1990)	= 0.19 - 0.29

*Does not include California south of Cape Mendocino.

13. OTHER ROCKFISH

By William H. Lenarz

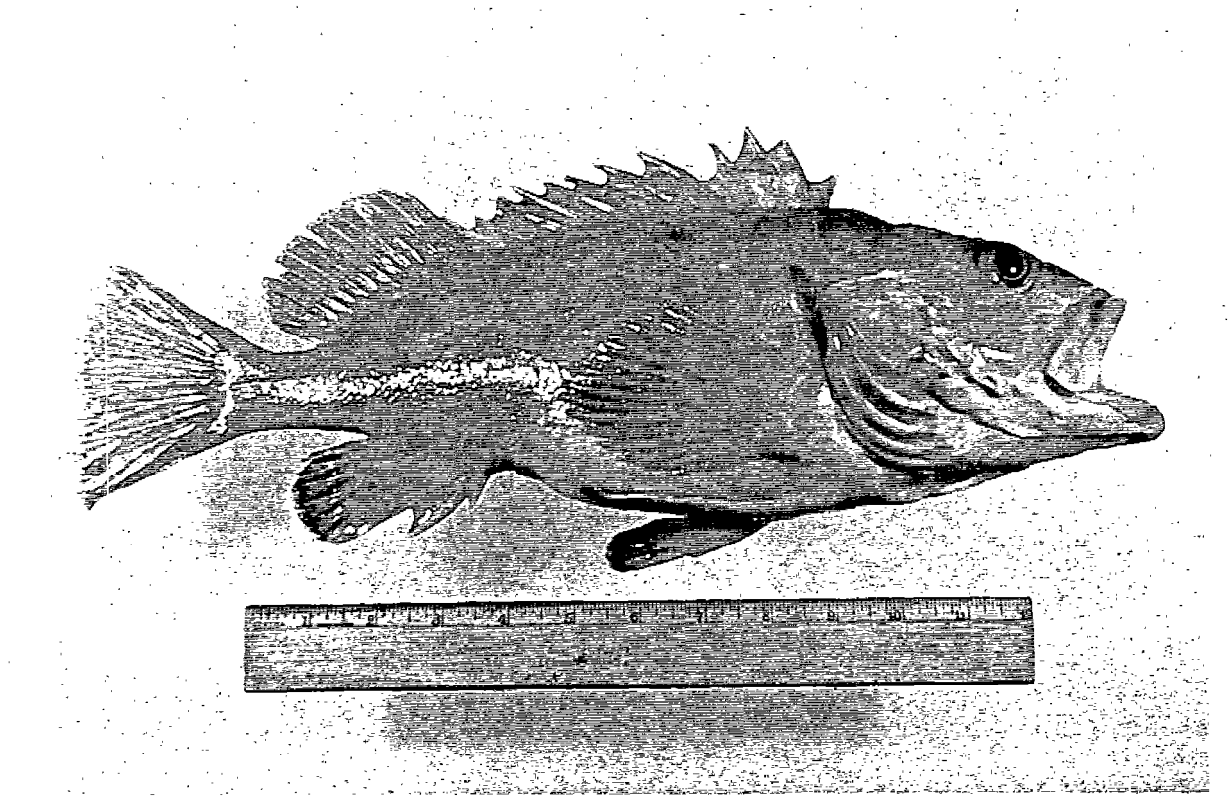


Photo: AFSC

There are in addition to those already mentioned, at least 50 other species of rockfish *(Sebastes* spp.) taken commercially along the U.S. West Coast (California, Oregon, and Washington). Most of the commercial harvest is taken by bottom trawl and hook-and-line gear over the continental shelf and upper slope. While some of the larger rockfish species reach sizes in excess of 90 cm [e.g., cowcod *(S. levis),* shortraker *(S. borealis),* yelloweye *(S. ruberrimus),* and rougheye *(S. aleutianus)* rockfishes], maximum lengths of most range between 30 and 60 cm. The genus includes. members that occupy a multitude of habitats and species that exhibit a great diversity of life history strategies. Some are solitary demersal forms while others shoal in the open ocean.

One feature held in common by all m&fish, however, is viviparous reproduction. In general, copulation occurs months before fertilization of the eggs occurs. The larvae develop internally and usually are extruded by the female sometime between December and June. The pelagic larval-juvenile period is quite variable although some species are at least 5-6 months old when settlement finally occurs. Reproductive success often varies substantially from year to year, creating large differences in year-class strength. It is

OTHER ROCKFISH
Pacific Coast

Average commercial catch (1984-91)	= 14,112 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1991)	= 14,000 t
Importance of recreational fishery	= Major
Management	= Groundfish FMP
Status of exploitation	= Unknown
Length at 50% recruitment	= Unknown
Length at 50% maturity	= Females: 15-41 cm Males: 16-40 cm
Assessment approach	= Length trends
Fishing strategy	= None
F (1991)	= Unknown

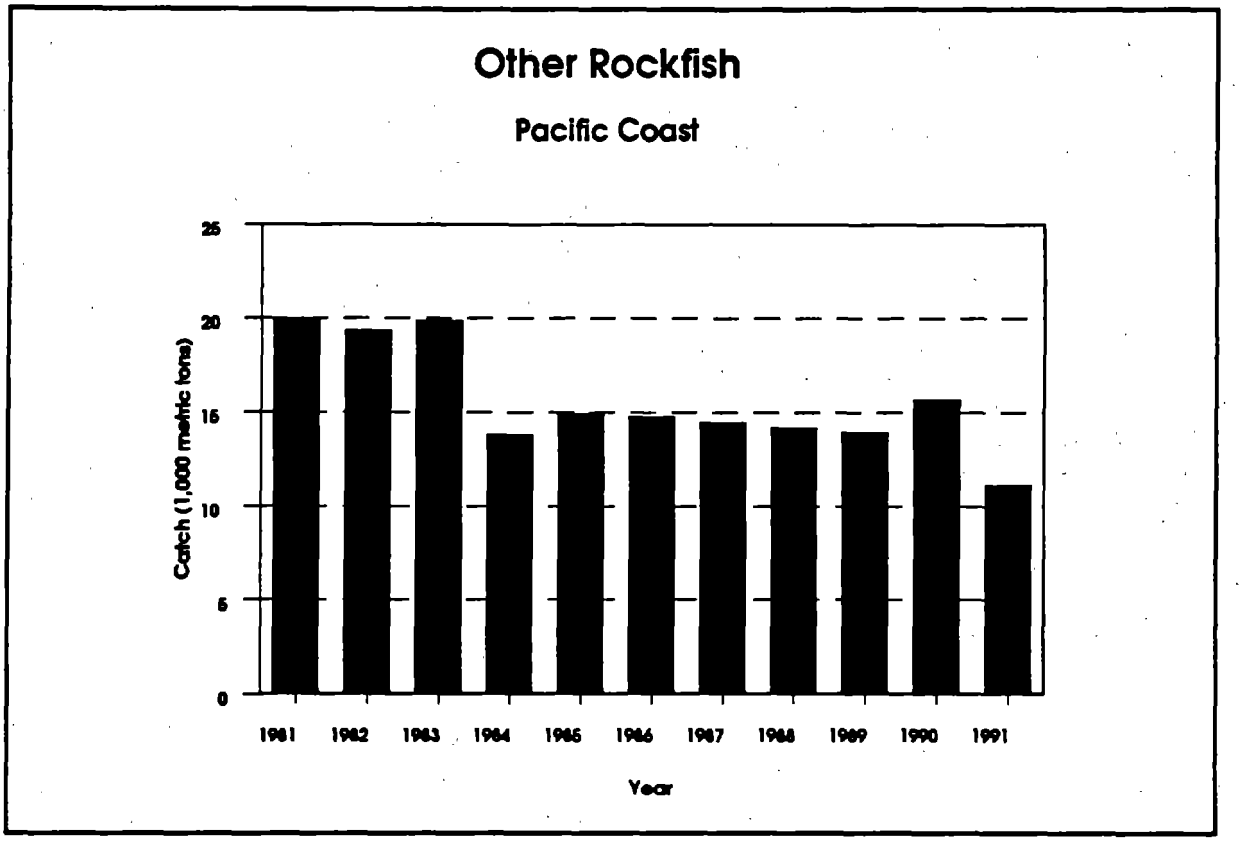
also commonplace within the genus for growth to proceed quite slowly. Many species are known to reach ages substantially in excess of 50 years.

The majority of rockfishes reside on the continental shelf in water depths shallower than 100 fathoms. Many of these species prefer rocky habitats although some of the more abundant species are found in regions of low relief. Feeding habits within the genus are highly variable, ranging from omnivorous (blue rockfish, *S. mystinus)* to the largely piscivorous diets of the large species. Small rockfish tend to feed predominantly on benthic crustaceans while still other feed largely on planktonic organisms, principally krill.

Due to the large number of rockfish species caught in the West Coast groundfish fishery. it is not feasible to perform stock assessments for all individual species. However, catch data obtained over the last decade through the Pacific Fishery Information Network (PacFIN) show that total landings of other rockfish declined from 20,000 t in 1981 to 13,800 t in 1984. This represents a 31% decline in 4 years. Because much of this change may simply have been due to improved market recognition of widow, bocaccio, chilipepper, canary, and yellowtail rockfishes during the 1981-84 timeperiod, it is uncertain what may have caused the drop. Since 1984, landings have fluctuated with no clear trend.

Although no detailed stock assessments have been conducted on these species to date, there is evidence that they are under significant fishing pressure. One recent study examined length-frequency data from commercial trawl landings of 11 rockfishes at central and northern California ports. Results showed distinct declining trends in the mean size of fish caught as well as drops in the 10th and 90th length percentiles. Similar trends were observed in both males and females of the species. Moreover. simple population models showed that, to bring about length reductions equivalent to those that were observed, substantial fishing pressure must have taken place.

These species are currently managed under the Groundfish FMP of the PFMC. Based upon historical levels of catch, the 1991 ABC was set at 14,000 t. In addition. there is a coastwide *Sebastes* complex trip limit of 11.3 t (25,000 lb).



OTHER ROCKFISH
Pacific Coast
COMMERCIAL LANDINGS (t)

Species	1983	1984	1985	1986	1987	1988	1989	1990	1991
Black	374	215	100	172	82	181	137	24	106
Darkblotched	407	984	1,351	881	2,212	1,390	866	935	967
Redstripe	411	134	309	206	247	321	329	281	209
Sharpchin	213	77	272	182	186	346	342	129	211
Silvergrey	263	138	299	276	181	216	173	93	320
Splitnose	96	536	703	263	229	206	190	168	227
Yelloweye	177	83	97	76	115	120	160	67	185
Yellowmouth	498	453	712	288	237	418	334	331	599
Other	1,710	1,956	1,742	1,978	1,979	1,341	1,763	1,361	2,053
Unspecified	15,696	9,228	9,347	10,446	8,999	9,640	9,644	12,284	6,258
Total	19,845	13,803	14,932	14,767	14,468	14,177	13,939	15,673	11,135

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By Benjamin J. Turnock

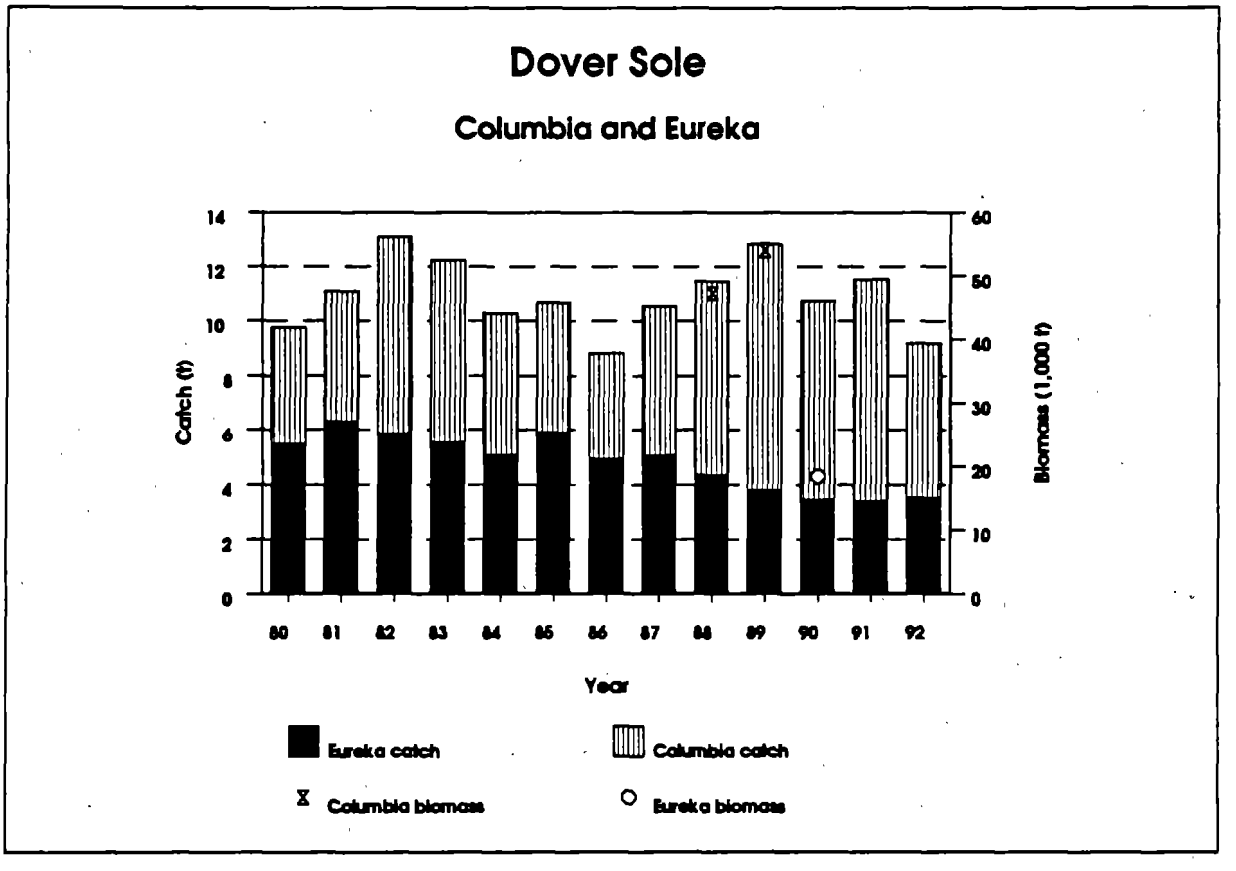
Dover sole *(Microstomus pacificus)* occur from northern Baja California to the Bering Sea in waters as deep as 600 fathoms. Abundance is highest in the 200 to 300 fathom range. Tagging studies indicate that fish migrate to deeper water to spawn in winter and back to shallower water in summer. Superimposed on this seasonal migration is the tendency for Dover sole to gradually move to deeper water with age. Prey consists mainly of burrowing invertebrates. Females grow faster and attain larger sizes (maximum size 60-70 cm) than males (maximum size about 50 cm). Maximum age is about 50 years. Natural mortality is estimated at 0.10.

Dover sole are caught commercially chiefly by bottom bawls. Dover sole, sablefish, and thornyheads occur in similar habitat and are often caught together. Coastwide catches increased from 14,000 t in 1980 to about 20,000 t from 1982 to 1985, then declined to 16,000 t in 1992. The fishery has gradually moved into deeper water in recent years. Catches in the Eureka INPFC area (Cape Mendocino, California, to Cape Blanco, Oregon) have declined from 5,800 t in 1982 to 3,500 tin 1992. Catches in the Columbia INPFC area (from Cape Blanco, Oregon, to 47°30'N lat.) increased in the early 1980s, declined in the mid-1980s and increased to a high of 9,000 t in 1989. Catches have declined since 1989 to 5,665 t in 1992.

DOVER SOLE
Pacific Coast
COMMERCIAL CATCH (t)

Year	Catch
1983	19,600
1984	19,000
1985	20,300
1986	16,100
1987	18,000
1988	17,700
1989	18,700
1990	15,700
1991	18,200
1992	16,000

Stock assessments have been conducted for the Columbia and Eureka INPFC areas only. Estimates



of biomass from surveys in the Columbia INPFC area have declined from 62,000 t in 1975 to 47,215 tin 1988 and 53,978 t in 1989. A 1990 survey in the Eureka INPFC area estimated biomass at 18,368 t, which resulted in the ABC in the Eureka INPFC area being lowered from 8,000 t to 4,900 t in 1991 and to 3,500 t for 1993. The ABC in the Columbia INPFC area was lowered in 1990 from 11,500 t to 6,100 t as a result of the 1990 stock assessment The 1993 ABC has been set at 4,000 t This latest assessment was based on size and otolith-age data instead of biased scale-age data used in the previous assessment Fisheries in both the Columbia and Eureka INPFC areas appear to be fully exploited.

DOVER SOLE
Pacific Coast

Columbia INPFC Area

Average commercial catch (1980-92)	=	6,092 t
Long-term potential yield (MSY)	=	2,700 t
Acceptable biological catch (1993)	=	4,000 t
Importance of recreational fishery	=	Minor
Management	=	Groundfish FMP
Status of exploitation	=	Fully exploited
Length at 50% recruitment	=	32 cm (females) 32 cm (males)
Length at 50% maturity	=	34 cm (females) Unknown (males)
Assessment approach	=	Size-structured, separable assessment
Fishing strategy	=	$F_{35\%}$ = 0.12
F (1992)	=	0.11

Eureka INPFC Area

Average commercial catch (1980-92)	=	4,844 t
Long-term potential catch (MSY)	=	3,800 t
Acceptable biological catch (1993)	=	3,500 t
Importance of recreational fishery	=	Minor
Management	=	Groundfish FMP
Status of exploitation	=	Fully exploited?
Length at 50% recruitment	=	32 cm (females) 32 cm (males)
Length at 50% maturity	=	34 cm (females) Unknown (males)
Assessment approach	=	Size-structured, separable assessment
Fishing strategy	=	$F_{35\%}$ = 0.11
F (1992)	=	0.13

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By Martin W. Dom

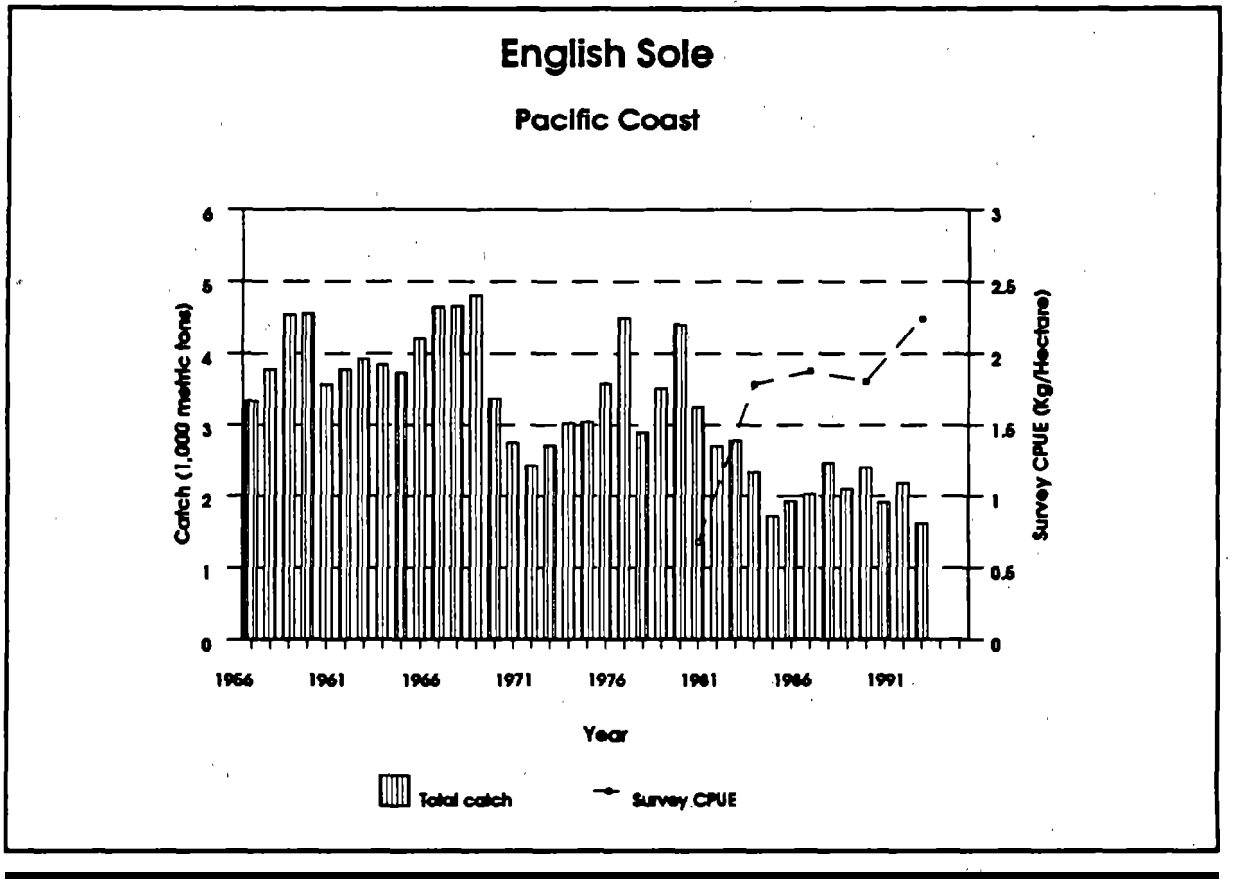
The English sole *(Pleuronectes vetulus)* is a small shallow-water flatfish commonly found in sand substrate habitats from Baja California to Unimak Island in the Aleutian Islands. Juvenile English sole are found in estuaries and in very shallow coastal waters, while adults move into deeper water on the continental shelf. Most of the population occurs at depths less than 50 fathoms. English sole spawn in winter, with a spawning peak in January or February. Their diet consists of benthic organisms, such as clams, clam siphons, segmented worms, small crabs, shrimp and brittle stars.

Female English sole grow more rapidly than males. The asymptotic length of females is 42.6 cm, while that of males is 36.3 cm. Length at 50% maturity is 31 cm for females and 22 cm for males. A tagging study by the Oregon Department of Fish and Wildlife in 1975 found that most English sole do not migrate long distances along the coast. English sole undergo a seasonal movement from deep water to shallow water in the spring and a return migration to deeperwaterinthe winterthatmaybe related to spawning.

English sole are primarily caught by the near-shore trawl fishery that captures a mix of flatfish including rex sole *(Errex zachirus)*, petrale sole *(Eopsetta jordani)*, and starry flounder *(Platichthys stellatus)*. English sole have a long history of full exploitation on the West Coast Thelanded catch of English sole is widely distributed, with significant landings ranging from Monterey to ports in northern Puget Sound. The landed catch consists mostly of females (about 94% by weight) because of the smaller average size of males. The average

ENGLISH SOLE
Pacific Coast
COMMERCIAL CATCH (t)

Year	Catch
1983	2,335
1984	1,722
1985	1,929
1986	2,028
1987	2,481
1988	2,102
1989	2,408
1990	1,913
1991	2,185
1992	1,615



ENGLISH SOLE
Pacific Coast

Average commercial catch (1983-92)	=	2,072 t
Long-term potential yield (MSY)	=	Unknown
Acceptable biological catch (1993)	=	1,900 t
Importance of recreational fishery	=	Minor
Management	=	Groundfish FMP, Mesh size regulation
Status of exploitation	=	Fully exploited
Age at 50% recruitment	=	Unknown (males) 4.1 years (females)
Length at 50% maturity	=	22 cm (males) 31 cm (females)
Assessment approach	=	Virtual population analysis
Fishing strategy	=	Not available
F (1992)	=	Unknown

annual catch during 1980-92 was 2,267 t. Catches declined steeply from 1980 to 1984, and have been fairly stable since 1984 at approximately 2,000 t annually. This annual yield is considerably less than the 3,738 t average annual catch over the 24-Year period from -1956 to 1979. The annual ex-vessel value of English sole landings averaged $1.41 million from 1990 to 1992. Analyses of the English sole population dynamics (virtual population analysis) conducted in 1984 and 1985 for the northern and southern components of the stock indicated that a series of years with weak recruitments was responsible for the recent downward trend in catches. Periods of strong and weak recruitment have occuered in the past and appear to be related to shifts in oceanographic conditions. Results of the triennial West Coast trawl surveys suggest that English sole biomass increased from 1980 to 1983, and then remained stable from 1983 to 1989. The 1992 survey suggests that English sole biomass is increasing. Abundance indices from these surveys should follow trends in stock abundance because the surveys cover a significant portion of the depth range of English sole and virtually all of its latitudinal range.

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By Benjamin J. Turnock

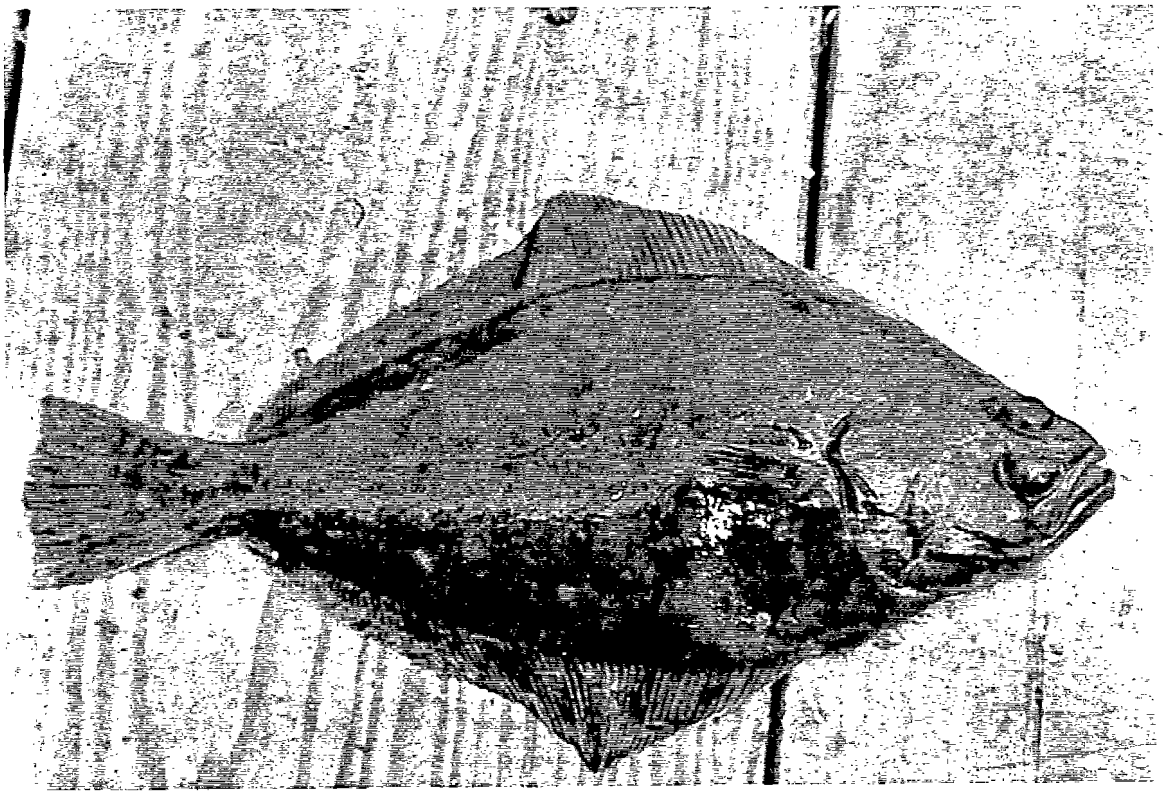

Photo: AFSC

The petrale sole *(Eopsetta jordani)* is distributed from northern Baja California to the Gulf of Alaska and the Bering Sea. Petrale sole are found in commercial abundance in water depths less than 100 fathoms, but the species can be found in depths up to 300 fathoms. Spawning takes place in late winter and early spring. Spawning has been documerited in Esteban Deep off central Vancouver Island and Willapa Deep off southern Washington. Recruitment is highly variable and dependent on oceano graphic conditions. Prey include euphausiids. sand lance, herring, and shrimp, as well as other bottom fish.

Maximum age exceeds 20 years for both males and females. Natural mortality is estimated to be in the range of 0.16 to 0.20. Maximum size is about 70 cm.

Petrale sole are caught commercially by bottom trawls. Coastwide catch increased from 2,050 t to 2,630 t in 1982. decreased to 1,730 t in 1986. increased again to 2,200 t in 1987, then decreased again to 1,510 t in 1992. The mean catch from 1980 to 1992 was 1,980 t About 50% of the catch comes from the Columbia INPFC area (from Cape Blanco, Oregon, north to 47°30'N lat. (near Cape Elizabeth) off central Washington. In this area, the mean catch from 1980 to 1992 was 975 t. Catch has remained fairly stable since 1956 and is currently near the historical mean catch of 900 t (from 1956 to 1979).

The most recent stock assessment of petrale sole was in 1987 for the Columbia INPFC area only. The 1990 ABCs for the total U.S. West coast and the Columbia INPFC area are 3,200 t and 1,100 t, respectively. Exploitable biomass in 1986 was

PETRALE SOLE
Pacific Coast
COMMERCIAL LANDINGS(t)

YEAR	Landings
1983	2,190
1984	1,740
1985	1,840
1986	1,730
1987	2,200
1988	2,140
1989	2,110
1990	1,770
1991	1,920
1992	1,510

estimated to be 2,611 t and F = 0.46.

Based on the results of triennial West Coast trawl surveys, coastwide biomass of petrale sole declined from 1980 to 1983, biomass was about the same in 1983, 1986, and 1992. In 1989 the biomass estimate was abut 80% higher than in other years.

For further information

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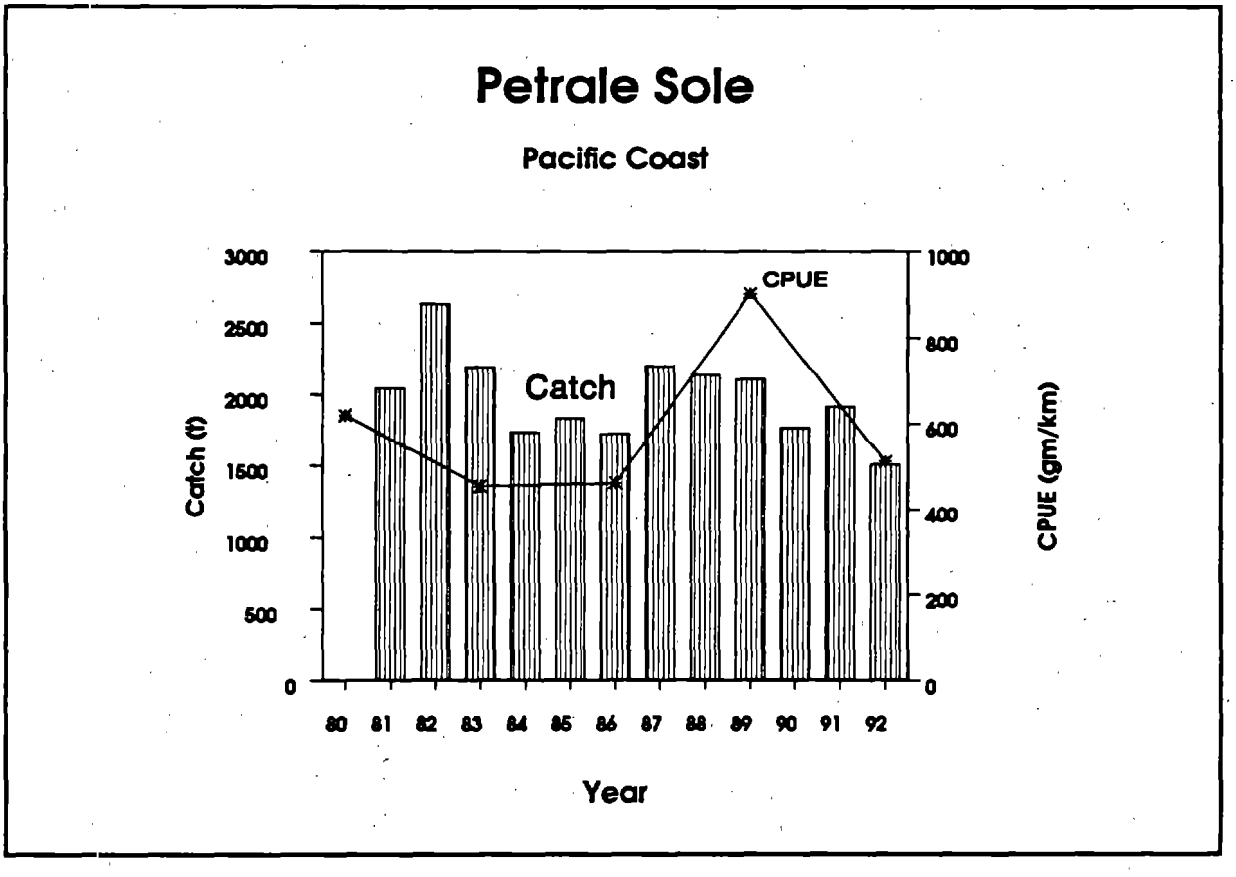
PETRALE SOLE
Pacific Coast

Average commercial catch (1983-92)	= 1,915 t
Columbia area only	881 t
Long-term potential yield (MSY)	= Unknown
Acceptable biological catch (1993)	= 3,200 t
Columbia area only	1,100 t
Importance of recreational fishery	= Minor
Management	= Groundfish FMP
Status of exploitation	= Fully exploited
Age at 50% recruitment	= 4.5 years (females)
	4.5 years (males)
Length at 50% maturity	= 40 cm (females)
	36 cm (males)
Assessment approach	= Abundance trend
Fishing strategy	= $F_{35\%}$ = unknown
F (1992)	= unknown



By Larry D. Jacobson

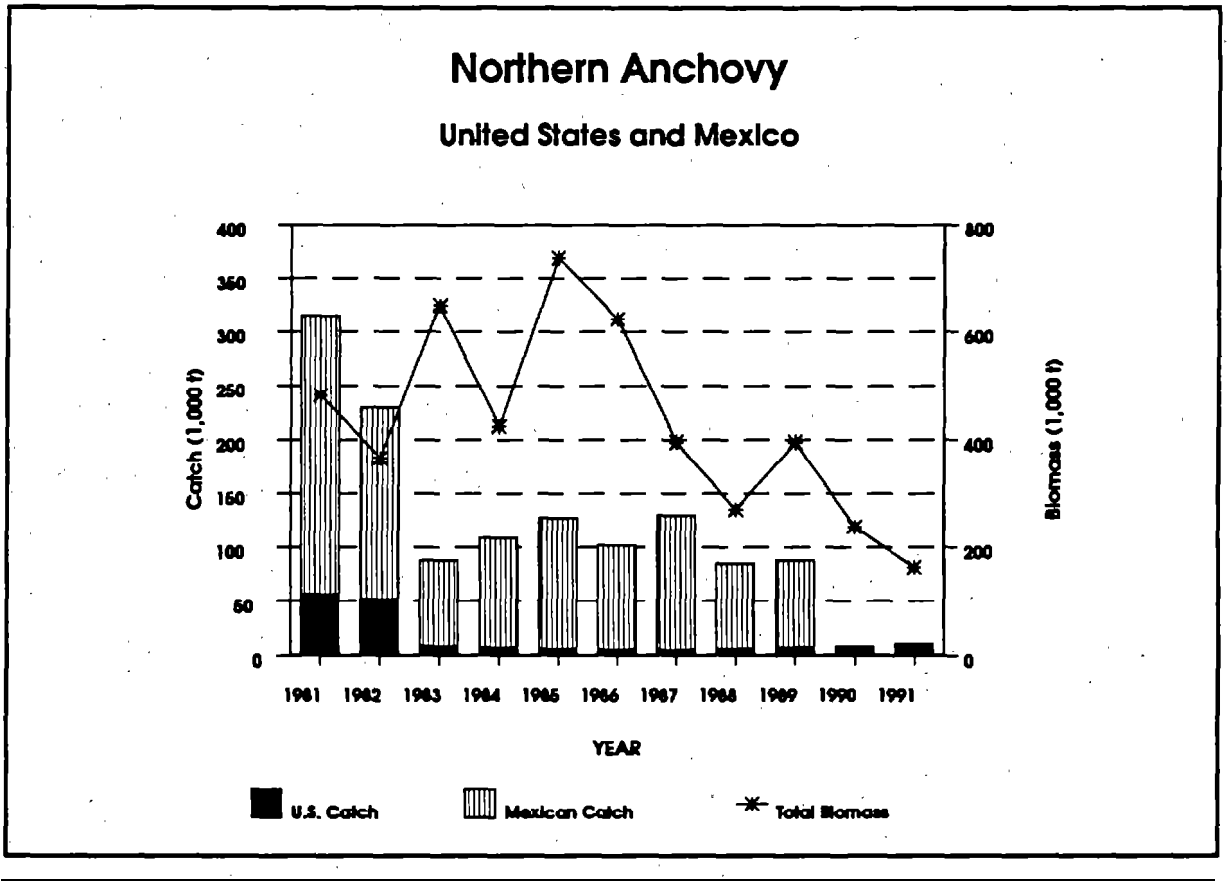
Northern anchovy *(Engraulis mordax)* are distributed from the Queen Charlotte Islands, British Columbia, to Magdalena Bay, Baja California. The population is divided into northern, central, and southern subpopulations or stocks. The central stock, which supports U.S. fisheries, ranges from approximately San Francisco, Califomia (38° N lat.), to Punta Baja, Baja California (30° N lat).

This small, short-lived planktivorous fish is typically found in schools near the surface in waters that range from 12° to 21.5°C. Anchovy rarely exceed age 4 and 18 cm total length. The rate of natural mortality for northern anchovy is thought to be about 0.8 yr^{1} or 55% per year in the absence of fishing.

Northern anchovy spawn throughout the year, but spawning increases during late winter and early spring and peaks during February to April. Both eggs and larvae are found near the surface. Anchovy are all sexually mature at age 2. The. percentage of 1-year-olds that are sexually mature in a given year depends on water temperature. Substantial numbers of zero and l-year-old northern anchovy are taken by both the reduction and nonreduction fisheries.

The central stock of northern anchovy has been exploited by fisheries in both California and Mexico. Anchovy landed by the reduction fishery are converted to meal, oil, and soluble protein products. Anchovy harvested by the live-bait fishery are not landed but kept alive for sale to anglers as bait and chum. Anchovy landed by the nonreduction (other than live bait) fishery are used as dead frozen bait; fresh fish for human consumption; and canned fish for human consumption, animal food, and anchovy paste.

Anchovy landed for reduction increased from 155 t in 1965 to 25,000 t in 1966. Landings ranged from 13,000 to 84,000 t per year during 1966-72. Landings increased to 118,000 t in 1973 and ranged from 73,000 to 142,000 t per year during 1973-77. In



response to decreases in fish meal prices, landings declined to an annual average of 39,000 t during 1978-82. Reduction landings have been extremely low since 1983, largely as a result of low prices paid to fishermen.

The average price for anchovy landed by the reduction fishery during the period 1974 to 1988 was about $63 per t (1989 dollars are used in this report) while the price paid during 1989 was only $36 per t Revenues (landings in t times dollars per t paid to fishermen) during 1989 were only $3,900. During the last year in which reduction landings exceeded 50,000 t reduction processors paid $82 per t

The livebait fishery takes a variety of species, but anchovies comprise about 85% of the catch. From 1981 to 1991, the anchovy live-bait catch ranged from 3,600 to 7,000 t per year and averaged 45,000 t annually. The price paid to fishermen for anchovy landed as live bait has been about $709 per t. On this basis. revenues in the live-bait fishery during 1989 were about $3.4 million.

Nonreduction (other than for live bait) landings averaged about 1,500 t per year from 1981 to 1991. From 1980 to 1988, the ex-vessel price of anchovy landed for nonreduction purposes other than live bait averaged about $300 per t. Revenues during 1989 (assuming $304 per t, 1988 value) were about $0.70 million.

Anchovy landings in Mexico are used primarily for reduction although a small amount is used as bait. Mexican landings reached a high of 259,000 t in 1981, fell to 178,000 t in 1982 and ranged between 79,000 to 124,000 t per year during 1983 to 1989. Mexican landings surpassed California landings in every year from 1977 to 1989 and comprised more than 90% of the total from 1983 to 1989. Mexican landings declined dramatically after 1989 and were 99 t and 831 t during 1990 and 1991, respectively. The decline in Mexican landings was due to low anchovy abundance and availability.

Northern anchovy fisheries have been managed by the PFMC since 1978 under a separate FMP but will be included in a new Coastal Pelagic Species FMP currenty under development. Current regulations impose no numeric limit on live bait catch and provide a 7,000 t quota for other nonreduction uses. The regulations also specify optimum yield for the reduction fishery as 1) zero when the spawning biomass is less than or equal to a cutoff level of 350,000 t, and 2) the difference between the spawning biomass and the cutoff, up to a limit of 200,000 t, when the spawning biomass is greater than 300,000 t. In the absence of a bilateral agreement, 70% of optimum yield is allocated to U.S. fisheries so that, for example, 0.7 x 7,000 t = 4,900 t is allocated each year for the U.S. nonreduction (other than live bait) fishery.

NORTHERN ANCHOVY
Pacific Coast
CATCH (t)

YEAR	U.S.	MEXICO	TOTAL
1982	51,837	177,587	229,424
1983	8,487	79,389	87,876
1984	7,302	101,118	108,420
1985	5,784	121,081	126,865
1986	5,504	96,417	101,921
1987	4,875	124,475	129,350
1988	5,656	79,230	84,886
1989	7,044	80,823	87,867
1990	8,050	99	8,149
1991	9,674	831	10,505

The biological rationale for the 300,000 t threshold in the optimum yield formula for reduction fishing is to prevent depletion of the resource and to provide an adequate forage reserve for marine fish. mammals, and birds. The well-being of ecologically dependent species, especially the endangered brown pelican, that feed on northern anchovy, is an important issue in the management of anchovy fisheries.

As a final safeguard against stock depletion, the management plan for northern anchovy defines overfishing as harvests of any kind when the spawning biomass during the current and preceding season falls below 50,000 t All fisheries (reduction, live bait, and other nonreduction) are closed in the second season if the spawning biomass falls below 50,000 t for two consecutive seasons and the closure continues in subsequent until until the spawning biomass equals or exceeds 50,000 t.

Although the central subpopulation of northern anchovy is a transboundry stock harvested by fisheries in Mexican as well as U.S. waters, there is no bilateral management agreement with Mexico. In the absence of such an agreement, fishery managers in the United States assume that U.S. fishermen are entitled to 70% of the total optimal yield and set

quotas on this basis.

Biomass of northern anchovy in the central subpopulation averaged 400,000 t from 1964 to 1970, increased rapidly to 1.8 million t in 1974, and then declined to 490,000 t in 1978. Since 1978, biomass levels have tended to decline slowly. The biomass in 1989 was 261,000 t. Although there is little evidence to support this hypothesis, the recent decline in anchovy abundance may be due to warm water conditions that have prevailedsince the mid-1970s or recent increases in sardine biomass. Maximum sustained yield of northern anchovy in the central stock (without making allowances for feeding by some ecologically dependent species and ignoring variation in environmental factors that cause changes in abundance) is estimated to be about 219,000 t per year at a total biomass level of about 586,000. implying an optimal exploitation rate of about 37%. Exploitation rates exceeded 37% three times (1980 to 1982) during the history of the fishery.

NORTHERN ANCHOVY
Pacific Coast

Average catch (1981-91):	U.S.	= 18,890 t
	Mexico	= 113,796 t
	Total	= 132,686 t
Long-term potential catch (MSY)		= 219,000 t
Optimum yield in 1991:	U.S. reduction	= 0 t
	U.S. nonreduction	= 4,900 t
	U.S. live bait	= Unrestricted
	U.S. total	= 4,900 t
	Mexico reduction	= 0 t
	Mexico nonreduction	= 2,100 t
	Total	= 7,000 t
Importance of recreational fishery		= Significant (bait)
Management		= Pacific northern anchovy FMP
Status of exploitation		= full; 1990-91
Age at recruitment		= 0-1 years
Age at maturity		= 1-2 years
Assessment approach		= Stock synthesis model
Management strategy		= Optimum yield formula based on annual spawning biomass estimate
F (1991)		= < 0.05

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18. JACK MACKEREL

By Alec D. MacCall

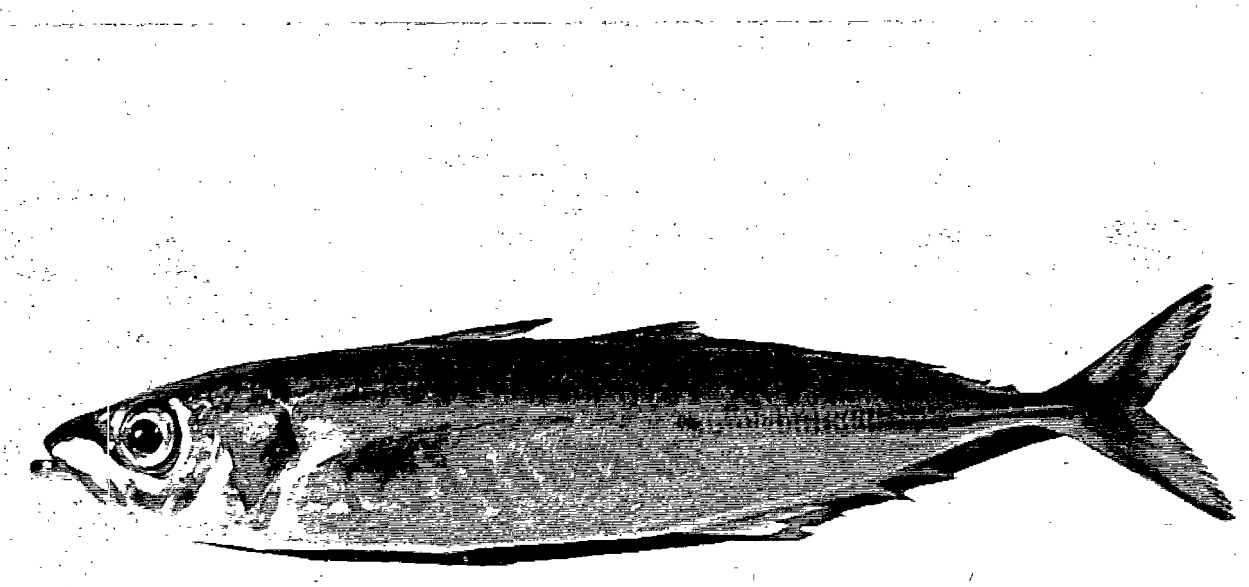

Photo: SWFSC

The jack mackerel *(Trachurus symmetricus)* is a member of the family Carangidae (the Jacks), and is similar to several other species of *Trachurus* (horse mackerel) that occur in temperate eastern boundary currents worldwide. Spawning occurs from central Baja California to British Columbia, moving northward from spring through late summer. Juveniles appear in the Southern California Bight, which serves as a nursery ground for several years after spawning. Older fish move offshore and northward and may be found hundreds of miles from shore (well beyond the U.S. EEZ), especially in the Pacific Northwest Individual jack mackerel found in offshore waters may exceed 30 years of age. Most female Jack mackerel in the Southern California Bight attain reproductive maturity as 1-year-olds.

The southern California segment of the stock has been fished since the late 1940s, when jack mackerel served as a substitute target for the failing sardine fishery. The southern California purse seine fishery has continued at a low level since then. Jack mackerel and Pacific mackerel *(Scomber japonicus,* elsewhere known as chub mackerel) are not distinguished on landings receipts and are considered to be commercially equivalent. However, jack mackerel is slightly less favored by purse seine fishermen due to its tendency to occur farther from port and over rocky bottoms, where there is increased risk of damage to nets. The southern California fishery is not yet managed under the MFCMA, and currently there is no limit on allowable catch.

The large adults, which occur offshore, are sometimes taken incidentally in trawls, particularly when Pacific whiting are targeted. During the 1970s foreign trawl fisheries may have caught 1,000-2,000 t annually, but catches by foreign and joint-

venture fishermen in the 1980s have ranged from zero to about 100 t Because of the foreign trawl fisheries of the 1970s, management of jack mackerel was initially placed in the Groundfish FMP of the PFMC., An annual incidental catch of 12,000 t (north of lat 39° N.) was used to account for incidental harvest while avoiding constraints on fishing for other groundfish species, particularly Pacific whiting. In 1991, there was increased interest by foreign, joint-venture, and domestic industries, and the ABC was raised to 52,600 t to allow development of a, fishery.That fishery failed to materialize.

The PFMC is in the process of transferring management of jack mackerel from the Groundfish FMP to a new Coastal Pelagics FMP. This will have the advantage of treating both the southern California and the offshore segments of the resource in the same management plan,

Stock size is thought to be 1.5 million t, and potential yield is unknown. Development of more reliable estimates of stock size and potential yield awaits collection of additional information about age structure and reproductive biology, which could be used to interpret existing CalCOFI egg-and-larval-survey data. The extensive geographic distribution and heterogeneous structure of the resource may make management and assessment of the resource difficult. Trawl, ichthyoplankton, or hydroacoustic surveys for jack mackerel population assessment will be too large in geographic scope and too expensive to conduct regularly. Much of the necessary information will have to be obtained from the fishery, including catch rates and samples of fish for demographic and physiological analysis.

JACK MACKEREL
Pacific Coast

Average catch (1981-91)	= 12,200 t
Long-term potential yield (MSY)	= 100,000 t
Acceptable biological catch (1991)	= 52,600 t
Importance of recreational fishery	= Minor
Management	= Groundfish FMP
Status of exploitation	= Light
Age at 50% recruitment (offshore)	= 15 years
S. California	= 1 year
Age at 50% maturity	= 1 year
Assessment approach	= Ichthyoplankton
Fishing strategy	= Incidental catch not managed
F (1991)	= 0.01

For further information

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19. PACIFIC MACKEREL

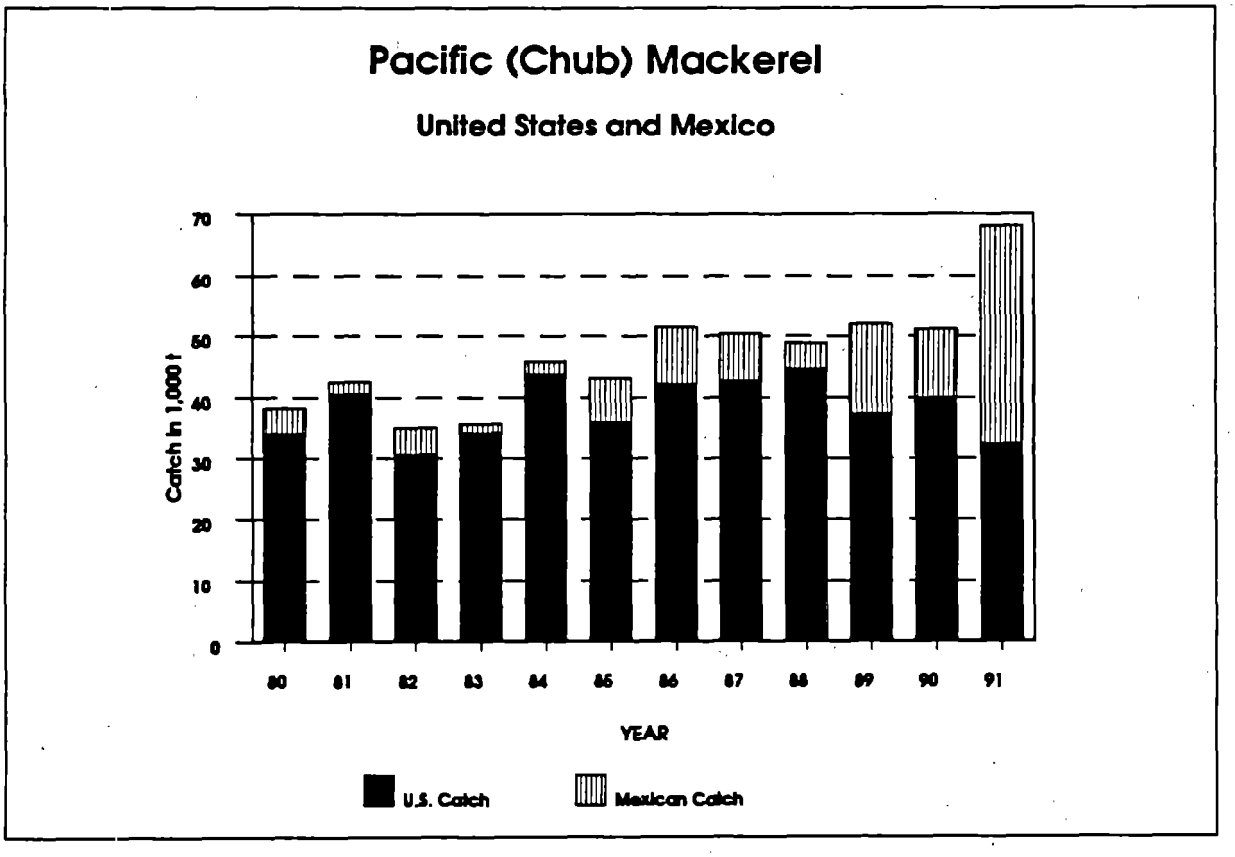
By Larry D. Jacobson

Pacific or chub mackerel *(Scomber japonicus)* has a worldwide distribution in temperate and subtropical seas. In the eastern Pacific Ocean, it ranges from central Mexico to Southeast Alaska including the Gulf of California, and is most abundant south of Point Conception, Califomia. It is usually found within 32 km of shore and often schools with other pelagic species such as jack mackerel and Pacific sardine. It is often caught, sold, and processed along with jack mackerel

Pacific mackerel are harvested by commercial fisheries in California and Mexico and is sold fresh, canned for human consumption and far pet food, or reduced as fish meal and oil. Commercial catches in the United States have been steady (average 38,000 t per year) since 1980, serving as the mainstay of the southern Califomia purse seine fishery. Mexican commercial catches (average 8,000 t per year since 1980) have recently increased- Total commercial landings have averaged about 46,000 t per year. Pacific mackerel is common in the recreational catch, especially in southern califomia, but is seldom a target species. During the period from 1980 to 1989, the California recreational catch averaged about 1,500 t per year. Older fish move north in the summer and south in the winter between Oregon and Baja California. with northerly movement most pronounced during El Niño events.

PACIFIC (Chub) MACKEREL
Pacific Coast
CATCH (t)

YEAR	U.S.	MEXICO	TOTAL
1980	33,984	4,238	38,222
1981	40,425	2,063	42,488
1982	30,533	4,518	35,051
1983	34,059	1,562	35,621
1984	43,612	2,129	45,741
1985	35,867	7,267	43,134
1986	42,098	9,387	51,485
1987	42,543	789	43,332
1988	44,446	4,472	48,918
1989	37,180	14,887	52,067
1990	39,839	11,375	51,214
1991	32,168	35,767	67,935



PACIFIC (Chub) MACKEREL
Pacific Coast

Average catch (1981-91):	U.S.	= 38,063 t
	Mexico	= 8,205 t
	Total	= 46,268 t
Long-term potential catch (MSY)		= 29,000 t
Current potential yield		= 29,000 t
Importance of recreational fishery		= Moderate
Management		= State of California (to be included in a new FMP for Coastal Pelagic Species)
Status of exploitation		= Fully exploited
Age at recruitment		= 1-2 years
Age at maturity		= 1-2 years
Assessment approach		= Catch-at-age analysis
Management strategy		= Quota formula based on annual biomass estimate
F (1991)		= 0.2-0.4

There is an inshore-offshore migration off California with abundance increasing inshore from July to November and offshore from March to May.

Pacific mackerel reach 63 cm in length although fish taken commercially seldom exceed 40 cm in length or a weight of 1 kg. Some fish mature at age 1 and all individuals are sexually mature by age 4. Most fish caught commercially are less than age 4 and enter the fishery during their first year of life. They become fully available to the fishery at about age 4. The rate of natural mortality for Pacific mackerel is thought to be about 0.5 yr^{-1} or 39% per year in the absence of fishing. Recruitment is variable and loosely linked to spawning biomass. Reproductive success, measured as spawning biomass divided by number of recruits. is highly variable and somewhat cyclic. The northeastern Pacific Ocean stock spawns from Baja California to northern California between 3 and 320 km from shore, primarily north of Point Conception from late April to July.

Biomass declined from almost 400,000 t in the early 1930s to less than 100,000 t in the late 1940s and early 1950s. After a brief resurgence in the early 1960s. biomass declined to 10,000 t (or lower) and remained low until strong year classes appeared in the late 1970s. Abundance increased dramatically after 1977 and probably exceeded 200,000 t in every year during the 1980s. Biomass is thought to be declining at present Analyses of fish-scale deposits in ocean bottom sediments in southern California indicate that the prolonged period of high mackerel biomass levels during the late 1970s and 1980s may have been unusual and is only expected to occur, on average, but once every 60 years.

Pacific mackerel are currently managed by the State of California but will be included in the new Coastal Pelagic Species FMP currently under development by the PFMC. If the estimated biomass is greater than 135,000 t, then commercial catch is not restricted by a quota If the biomass isbetween 18,000 and 135,000 t, then a quota equal to 30% of the biomass above 18,000 t is applied. If the biomass is below 18,000 t, then commercial fishing stops. It is estimated that Pacific mackerel might sustain average yields from 26,000 to 29,000 t per year under management systems similar to that currently used to manage the stock. As with sardine, the lack of a cooperative management agreement with Mexico is the most significant current problem in managing the Pacific mackerel stock.

For further information

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20. PACIFIC SARDINE

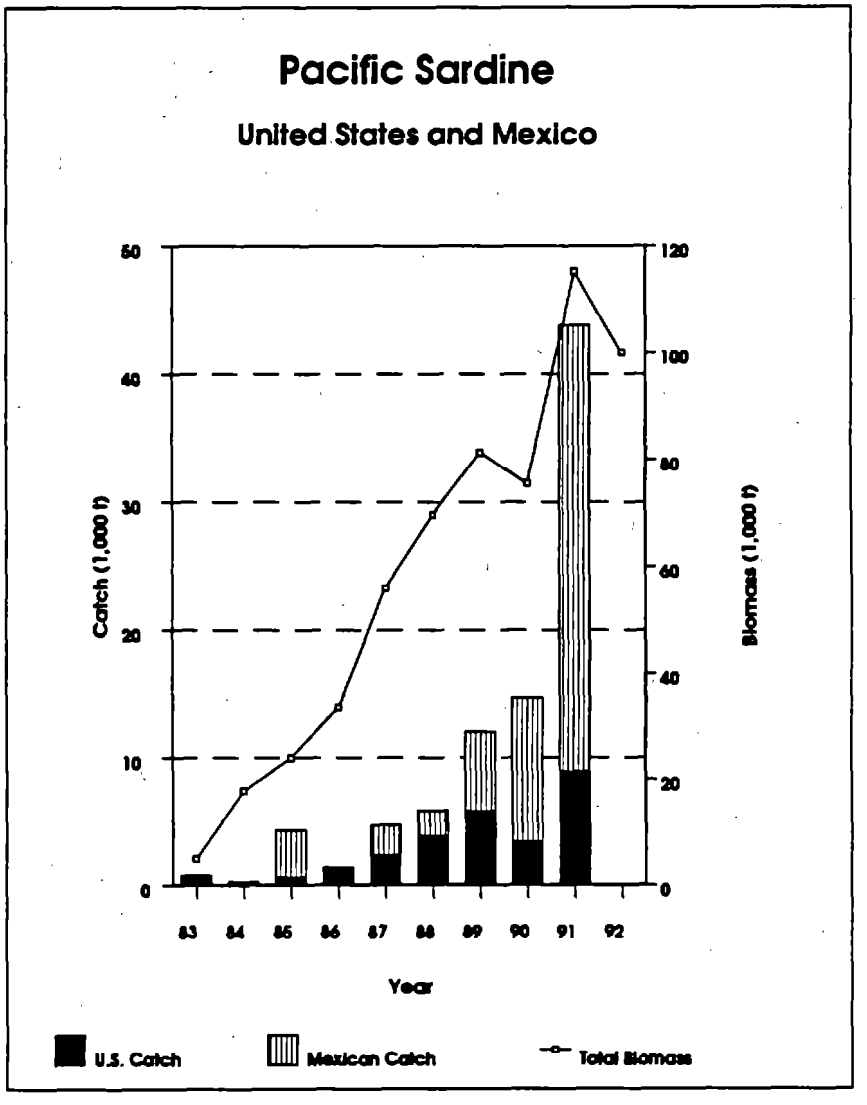
By Larry D. Jacobson

The Pacific sardine *(Sardinops sagax)* was, at the peak of its abundance, distributed in the northeast Pacific Ocean from Southeast Alaska to the Gulf of California Although primarily a coastal species, sardines have been observed as far as 560 km offshore. California fisheries have traditionally been most important in terms of total landings, but fisheries also existed off Oregon and Washington when sardines were abundant. Waters along the coast of southern California are the center of the Pacific sardine's distribution.

Like other small pelagic fishes. Pacific sardine are found in surface schools. They live as long as 10 years and may reach a length of slightly less than 30 cm. The rate of natural mortality for sardines is thought to be about 0.4 yr^{1} or 33% per year in the absence of fishing.

Historically, Pacific sardine has been harvested for reduction to fish meal and for use as bait as well as for human consumption. Currently. there is no reduction fishery for Pacific sardine in the United States, but fish are still taken for human consumption and bait. Mexican catches are used primarily for reduction to fish meal.

Pacific sardine supported the largest fishery in the western hemisphere (25% of all fish landed in the united States) during the 1930s and early 1940s when species abundance may have been as high as 2.5 million t Catches and abundance of Pacific sardine declined after the Second World War, with a short-term reversal during the 1950s, until the fishrey collapsed in the early 1960s. A complete moratorium on sardine fishing was imposed in California during the 1967-68 season due to low biomass levels. Prom 1986 to 1990. after abundance had increased somewhat, small quotas of about 1,500 t were allowed for commercial harvest in California In 1991, the California quota was increased to 27,000 t in response to increased biomass levels. The quota for California in 1991 was intended to allocate 50% of surplus production to the U.S. and Mexican fisheries and 50% to rebuilding the stock. Mexican landings since 1983, which have not been managed by quota, increased from 274 t in 1983 to 35,000 t in 1991. As with Pacific mackerel, the tack of a cooperative management agreement with



Mexico is the most significant problem in managing the sardine stock.

Pacific sardine are currently managed by the state of California but will be included in a new Coastal Pelagic Species FMP currently under development by the PFMC.

Abundance of Pacific sardine off southern California is increasing. Since 1986, stock biomass has increased by about 40% per year and current biomass is thought to be somewhere around 100,000 There appears to be considerable commercial demand for sardines and significant fisheries are expected to become reestablished as soon as larger quotas become available.

PACIFIC SARDINE
Pacific Coast

Average catch (1983-91):	U.S.	= 2,985 t
	Mexico	= 6,812 t
	Total	= 9,797 t
Long-term potential yield (MSY)		= 250,000 t (from a rebuilt stock)
Current potential yield		= 27,000 t
Importance of recreational fishery		= Moderate (as bait)
Management		= State of California (to be included in a new FMP for Coastal Pelagic Species)
Status of exploitation		= Fully exploited (at current stock level)
Age at recruitment		= 0-2 years
Age at maturity		= 1-2 years
Assessment approach		= Catch-at-age analysis
Management strategy		= One-half of surplus production to fishery, one-half to rebuilding the stock.
F (1991)		= 0.33

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PACIFIC SARDINE
Pacific Coast
CATCH (t)

YEAR	U.S.	MEXICO	TOTAL
1983	545	274	819
1984	299	0	299
1985	607	3,722	4,329
1986	1,183	243	1,426
1987	2,311	2,432	4,743
1988	3,835	2,035	5,870
1989	5,809	6,224	12,033
1990	3,364	11,375	14,739
1991	8,911	35,000	43,911

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P A C I F I C C O A S T S A L M O N

By Kenneth A. Henry

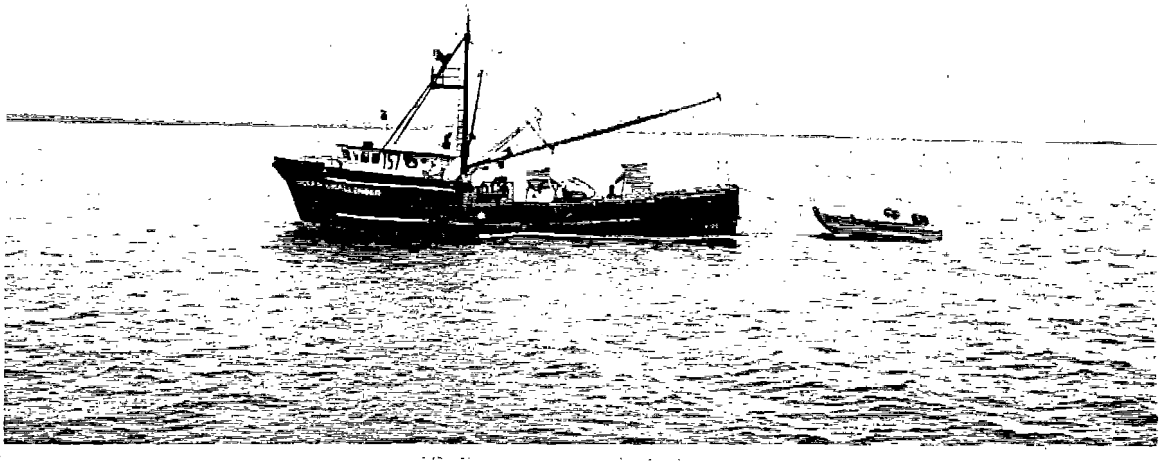


Photo: AFSC

This section describes the Pacific salmon stocks and fisheries off the Pacific Coast of Washington, Oregon, and California. The five species are the pink *(Oncorhynchus gorbuscha),* sockeye *(O. nerka),* chum *(O. keta),* coho *(O. kisutch),* and chinook (0. tshawytscha) salmon. The major fishery components are the commercial and recreational fisheries in Puget Sound, in certain Washington coastal rivers, in the Columbia River, in the Klamath River of California, and the ocean fisheries off all three states. These fisheries have been in existence since the late 1800s and are a continuation of fisheries conducted by Tribal fishermen. The pink., sockeye, and chum salmon catches occur primarily in Washington.

Pacific salmonareanadromous. They spawn in streams or lakes and migrate to the ocean where they may travel into international waters. Upon reaching maturity, they return to their home stream to spawn and complete their life cycle.

Management of this resource is complex. Some

ALL FIVE SALMON SPECIES
Pacific Coast
COMMERCIAL AND RECREATIONAL
(Catch in 1,000s of fish)

Year	Comm	Rec	Total
1980	5,261	1,304	6,565
1981	9,237	1,104	10,341
1982	7,474	1,144	8,618
1983	5,041	1,124	6,165
1984	4,631	854	5,485
1985	11,198	1,131	12,329
1986	9,054	1,299	10,353
1987	10,457	1,319	11,776
1988	7,828	1,292	9,120
1989	10,771	1,449	12,220
1990	5,903	1,252	7,155
1991	8,711	1,510	10,221
1992	3,210	969	4,179
Average			
1960-90	7,556	1,374	8,930
1990-92	5,941	1,244	7,185

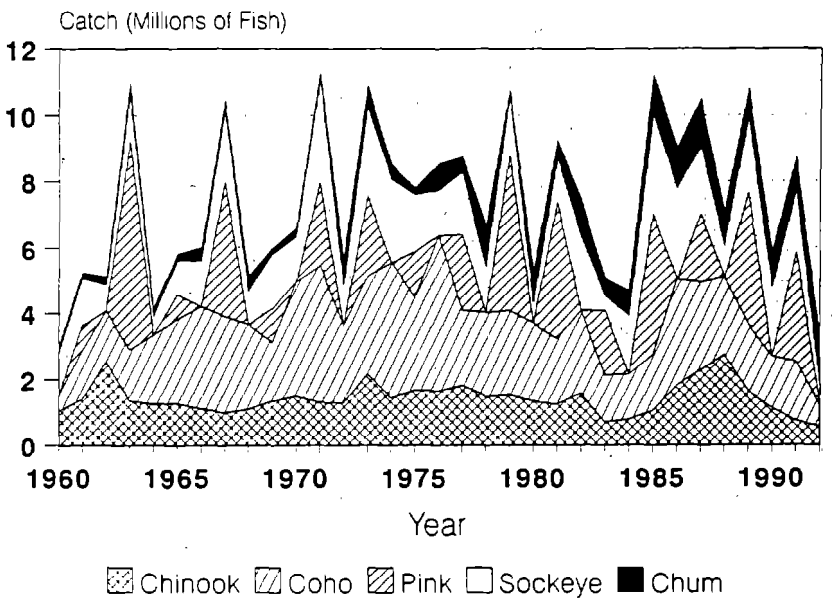
Pacific Coast Salmon Resources

Sockeye Salmon		
Average catch (1960-90)	=	1,654,000 fish
Average catch (1990-92)	=	1,524,000 fish
Long-term potential yield	=	2,839,000 fish
Importance of recreational fishery	=	minor
Status of Exploitation	=	fully exploited; overutilized
Fishing strategy	=	to meet spawning escapement goals and treaty obligations
Pink Salmon		
Average catch (1961-89)	=	2,921,000 fish
Average catch (1987-91)	=	3,191,000 fish
Long-term potential yield	=	3,496,000 fish
Importance of recreational fishery	=	minor
Status of Exploitation	=	fully exploited; overutilized
Fishing strategy	=	to meet spawning escapement goals and treaty obligations
Chum Salmon		
Average catch (1960-90)	=	644,000 fish
Average catch (1990-92)	=	1,184,000 fish
Long-term potential yield	=	1,017,000 fish
Importance of recreational fishery	=	minor
Status of Exploitation	=	fully exploited; overutilized
Fishing strategy	=	to meet spawning escapement goals and treaty obligations
Chinook Salmon		
Average catch (1960-90)	=	1,980,000 fish
Average catch (1990-92)	=	1,169,000 fish
Long-term potential yield	=	2,274,000 fish*
Importance of recreational fishery	=	20% of the total catch
Status of Exploitation	=	fully exploited; overutilized
Fishing strategy	=	to meet spawning escapement goals and treaty obligations
Coho Salmon		
Average catch (1960-90)	=	3,239,000 fish
Average catch (1990-92)	=	2,184,000 fish
Long term potential yield	=	3,231,000 fish
Importance of recreational fishery	=	25-30% of total catch
Status of Exploitation	=	fully exploited; overutilized
Fishing strategy	=	to meet spawning escapement goals and treaty obligations

* Long-term goals for some stocks have been stated as doubling of production primarily through significant improvements of freshwater habitat. If this is achieved, it would increase the long-term potential dramatically.

Pacific Salmon - Commercial Catch

Washington, Oregon and California



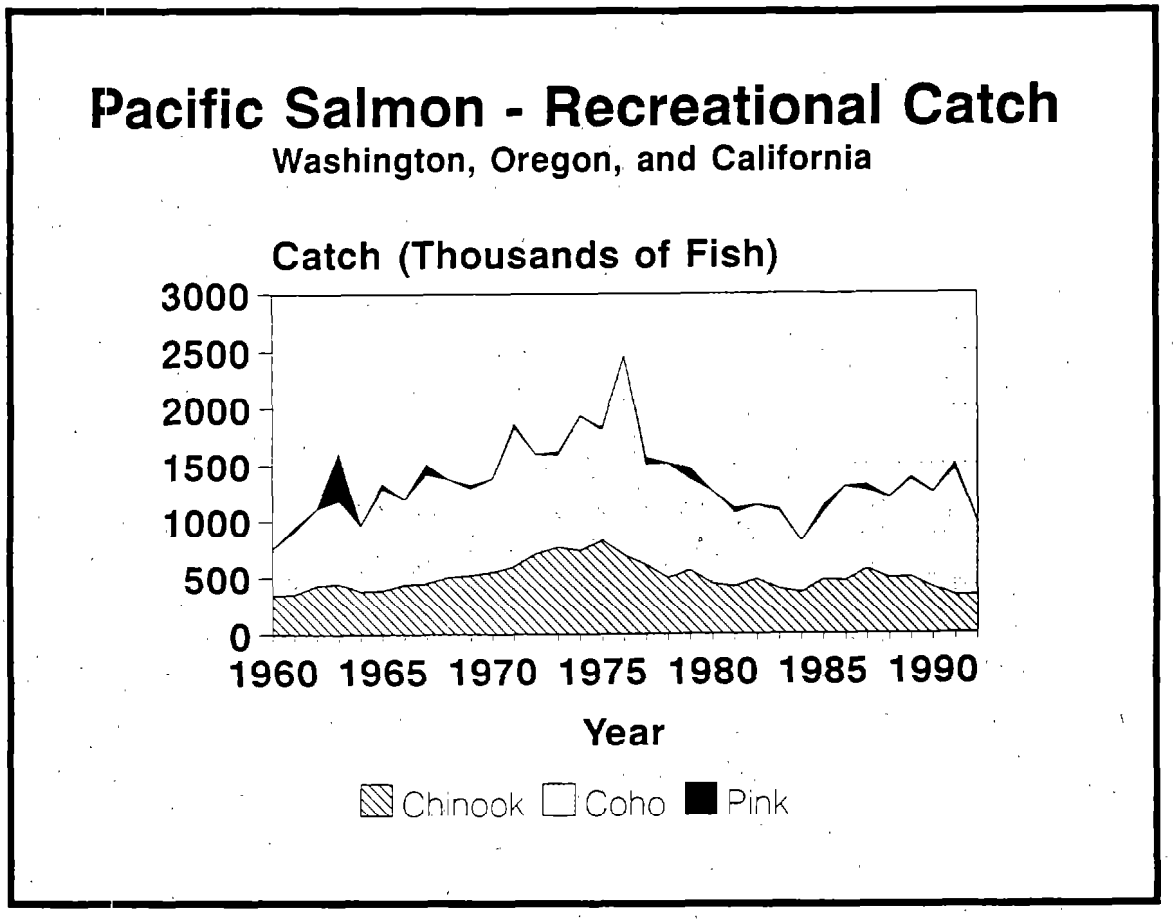
stocks are affected by management actions of the Pacific Salmon Commission (PSC), state fishery agencies, Indian management entities, and the PFMC. The U.S.-Canada Salmon Treaty signed in 1985 also covers the salmon fisheries from Southeast Alaska to northern Oregon, North-migrating stocks are impacted significantly by fisheries off Canada and Southeast Alaska, Only two species (chinook and coho salmon) are managed by the PMFC's Pacific salmon FMP.

Salmon catches and prices fluctuate considerably from year to year, due principally to variations in survival rates and production. Recently, the combined commercial landings of all five salmon species have had annual ex-vessel values of about $140 million with an average weight of about 36,197 t It is much more difficult to place a value on the recreational fishery. Some sport-caught salmon have been valued as high as $295 per fish. Nevertheless, it is clear that the average recreational catch for the past 3 years, 1.2 million salmon, is worth many millions of dollars.

In 1992, 2,336 commercial ocean troll boats took part in the fishery off California. Oregon, and Washington; down 38% from 1991. In the ocean recreational fishery, there were about 400,000 salmon angler trips or days; down 22% from 1991.

There is more fishing gear then is required to adequately harvest the Pacific salmon resources and severe limitations on fishing are required to protect the stocks. Thus. all five Pacific salmon species are listed as overutilized.

Changes in the freshwater environment have had devastating effects on the survival of salmon stocks. The large number of dams, particularly on the Columbii River, is one very visible factor. Dams that are completely impassable have eliminated large spawning areas. Dams that are passable to salmon still take their toll on returning adults. Also, conditions at dams cause significant losses of downstream migrating young salmon through delayed migrations and mortality from passing through the turbines. The lack of adequate water for fish passage has also been a problem. Improvement of the freshwater habitat and reduced mortality are needed to restore stocks.



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Sockeye salmon from Washington, Oregon, and California originate primarily from a few streams entering Puget Sound and the upper Columbia and Snake Rivers. Female sockeye salmon generally spawn from 3,000 to 4,000 eggs. The young fish typically migrate to the ocean after 1 or 2 years rearing in freshwater lakes. They normally mature after 2 or 3 years in the ocean and weigh from 1.8-3.6 kg, although Columbia River sockeye salmon are generally under 1.8 kg. Most return to their spawning grounds as 4-or 5-year old fish and are slightly less than 1 m long.

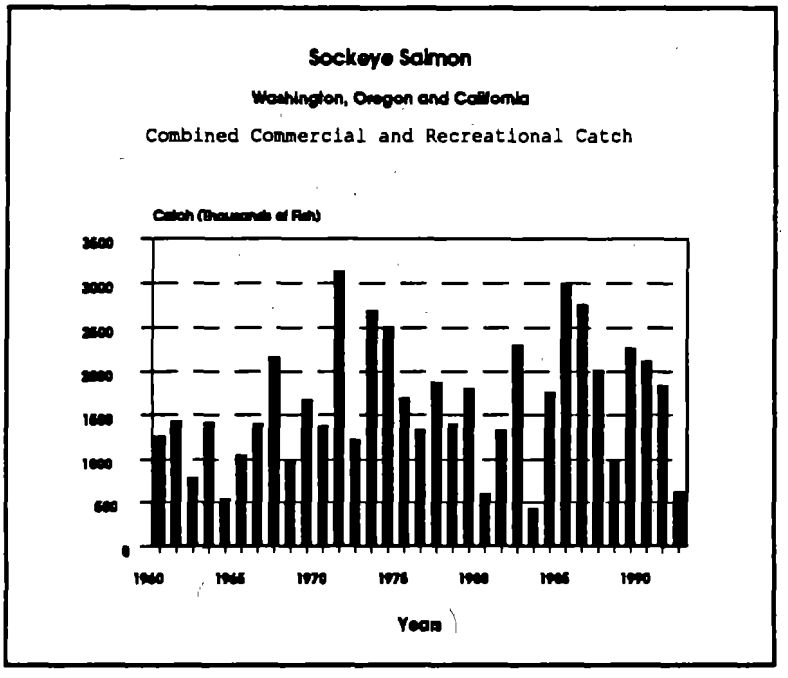
Most of the sockeye salmon are caught by gill net and purse seine, although the troll fishery also catches a sizable number. There is a popular recreational fishery for sockeye salmon on Lake Washington whenever the escapement exceeds spawning requirements. However, this has occured only six times since 1978. Most of the sockeye salmon caught by Washington fishermen are of Canadian origin returning prim&.lytotheFraser River.

The total annual Washington-Oregon sockeye salmon catch averaged 1.6 million fish from 1960 to 1992 and 1.5 million fish from 1990 to 1992. The recreational catch is small in proportion, averaging considerably less than 50,000 fish annually. Most of the sockeye salmon are produced from natural runs. Although Fraser River sockeye salmon runs have been at high levels of abundance in recent years, the number of fish that U.S. fishermen can harvest is limited under terms of the U.S.-Canada Salmon Treaty.

There is considerable concern about the status of the Snake River sockeye salmon. In December 1991, this stock was listed as endangered under the ESA. In 1988, there were only four adults and two redds (nests) reported in the spawning escapement; in 1989, one adult, one redd, and a second potential redd were observed; in 1990, no adults or redds were identified. In 1991, the run consisted of three males and one female. In 1992, there was just one lonely and extremely disappointed male. The depressed condition of this stock is almost certainly due to the destruction of the freshwater habitat and the construction of several dams on the Columbia and Snake Rivers. These increased hazards and changes in the freshwater habitat have caused the virtual demise of these fish.

SOCKEYE SALMON
Pacific Coast
COMMERCIAL AND
RECREATIONAL CATCH
(in 1,000s of fish)

Year	Comm	Rec	Total
1980	556	43	599
1981	1,327	0	1,327
1982	2,284	12	2,296
1983	402	28	430
1984	1,713	45	1,758
1985	2,993	1	2,994
1986	2,756	1	2,757
1987	2,005	5	2,010
1988	900	95	995
1989	2,261	1	2,262
1990	2,109	7	2,116
1991	1,837	1	1,838
1992	618	1	619
Average			
60-90	1,646	8	1,654
90-92	1,521	3	1,524



Pink salmon stocks for these three states originate primarily from tributaries of Puget Sound. Females usually bear 1,500 to 1,900 eggs. The fry migrate to salt water shortly after emerging from the gravel. They mature at age 2 weighing 1.4 to 2.7 kg; although fish up to 4.5 kg have been recorded In some areas, there are pink salmon returns every year (both odd-year and even-year cycles); but Puget Sound pink return on odd-year cycles.

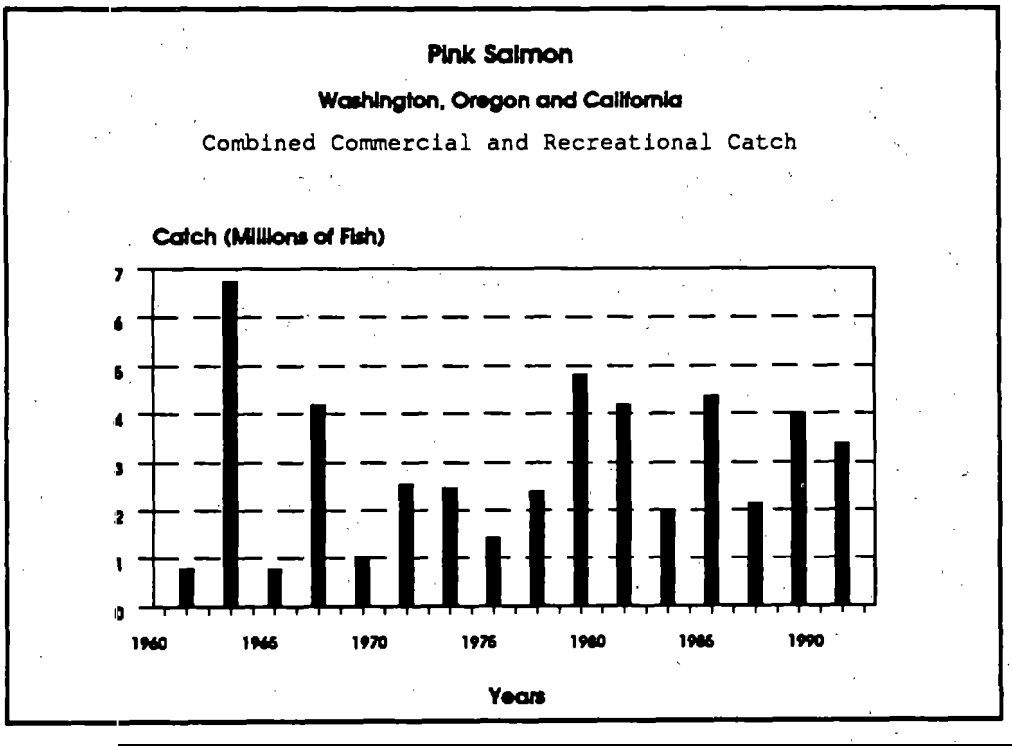
Most of the pink salmon are caught by net gear in Puget Sound; however, trollers have become more proficient in catching pink salmon in recent years. Most of the pink salmon caught by Washington fisheries are of Canadian origin returning to the Fraser River, although Washington origin pink salmon do contribute a significant catch in some years.

The 1961-91 commercial catch (odd years only) averaged 2.9 million pink salmon annually whereas the annual average for 1987-91 was 32 million pink salmon. The sport catch for the same two time periods averaged 72,000 and 42,000 pink salmon, respectively. Most of the pink salmon caught are from natural production. Although Fraser River: pink salmon stocks are at a high level of abundance, the U.S. catch has been restrained in recent years under terms of the U.S.-Canada Salmon Treaty.

The abundance of U.S. pink salmon stocks fluctuates considerably due to varying survival rates, but the stocks appear to be in good condition.

PINK SALMON
Pacific Coast
COMMERCIAL AND
RECREATIONAL CATCH
(in 1,000s of fish)

Year	Comm	Rec	Total
1971	2,499	40	2,539
1973	2,419	29	2,448
1975	1,408	23	1,431
1977	2,322	60	2,382
1979	4,708	103	4,811
1981	4,136	41	4,177
1983	1,953	21	1,974
1985	4,284	63	4,347
1987	2,088	52	2,140
1989	3,977	23	4,000
1991	3,321	52	3,373
Average			
61-89	2,844	77	2,921
87-91	3,129	63	3,191



23 CHUM SALMON

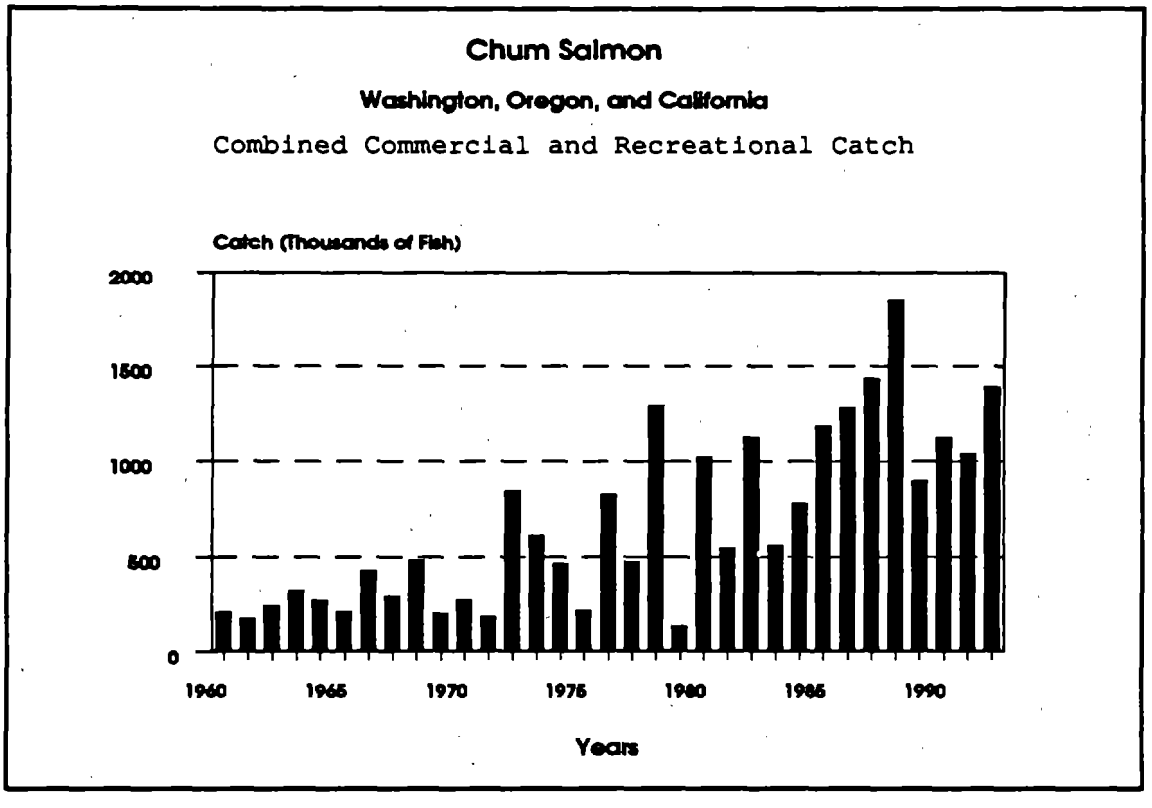
Most of the important chum salmon stocks along the U.S. West Coast originate in Puget Sound tributaries, but some stocks are also found in streams partway down the Oregon coast. Historically. chum salmon were abundant in the Columbia and Sacramento Rivers; however, at present this specie is rarely seen in California and is limited to the lower 300 km of the Columbia River, with more runs on the Washington side. Females spawn up to 2,700 eggs, and, as with pink salmon, the fry migrate to salt water shortly after hatching. Most chum salmon remain in the ocean from 2 to 4 years and then return to fresh water to spawn, weighing from 3.2 to 8.2 kg; although some as large as 9 kg have been sported.

Most chum salmon are caught in net gear. A portion of the catch is from Canadian stocks. From 1960 to 1992, catches averaged 718,000 chum salmon annually and from 1990-1992, averaged about 12 million chum salmon. Artificial production has been increasing, but the bulk of the production is from natural spawners. The recreational catch is very small

U.S. chum salmon stocks fluctuated due to varying ocean survival and conditions, but these stock appear to be in fairly good condition. Long-term studies of age and growth of chum salmon over the past 20 years show significant declines, particularly during the last decade, in the size of returning adult chum salmon.

CHUM SALMON
Pacific Coast
COMMERCIAL AND
RECREATIONAL CATCH
(in 1,000s of fish)

Year	Comm	Rec	Total
1980	1,018	2	1,020
1981	542	2	544
1982	1,120	1	1,121
1983	557	1	558
1984	779	1	780
1985	1,185	1	1,186
1986	1,283	2	1,285
1987	1,432	4	1,436
1988	1,848	5	1,853
1989	888	8	896
1990	1,115	6	1,121
1991	1,032	6	1,038
1992	1,387	6	1,393
Average			
60-90	642	2	617
90-92	1,178	6	1,184



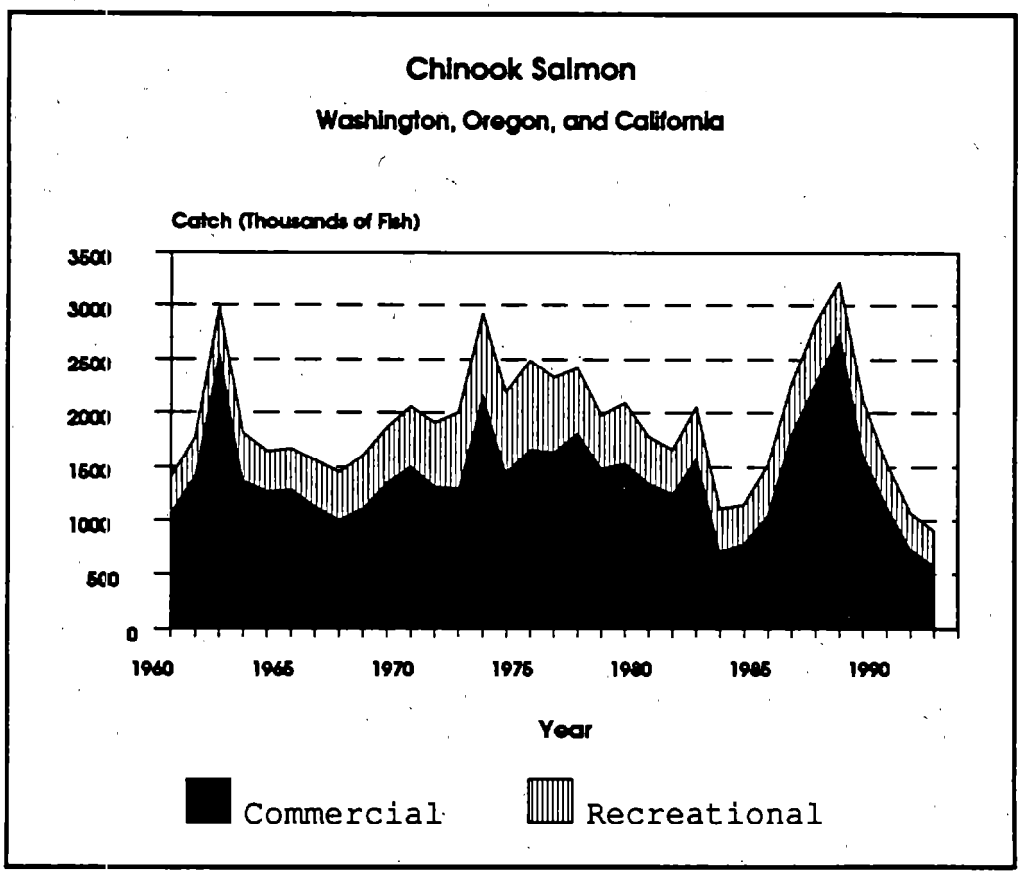
Chinook salmon spawn in streams and rivers from Puget Sound, Washington, to San Francisco: California, usually in larger tributaries, with the Columbia River system being a major producer. Other important producers of chinook salmon are Puget Sound. the Umpqua and Rogue Rivers in Oregon, and the Klamath and Sacramento Rivers in California. Chinook salmon stocks are laldledas spring, summer, fall or winter depending on their time of migration from the ocean into fresh water.

Females deposit from 3,000 to 14,000 eggs. Some young fish migrate to the ocean shortly after emergence from the gravel while others overwinter in fresh water before going to salt water. They spend from 2 to 5 years in the ocean before returning to fresh water to spawn and re-start the cycle again. Chinook salmon are the largest salmon with some adults weighing over 22.7 kg and reaching about 1.5 m in length. Most weigh from 7.7 to 22.7 kg at maturity. Some chinook salmon undertake long freshwater migrations to reach their home stream, particularly to the upper areas of the Columbia and Snake Rivers.

For the period 1960-92, commercial landings of chinook salmon, both natural and hatchery produced, have averaged 1.4 million fish, white recreational landings averaged 494,000 fish. The ocean chinook salmon catch north of Cape Falcon, Oregon, has been limited by annual catch quotas. Chinook salmon produced in hatcheries are contributing a significant share of these catches.

The NMFS has listed the spring-summer and fall chinook salmon runs in the Snake River as threatened under the ESA. Escapements for these stocks in recent years have been reduced considerably.

For upriver spring chinook salmon, the goals of 115,000 escaping above Bonneville Dam and 35,000 spring chinook salmon escaping above Lower Granite Dam have not been met since 1978. For upriver summer chinook salmon, the goal of 80,000-90,000 escaping above Bonneville Dam has not been met since before 1971. Also, the decreasing escapement of these fish above Lower Granite dam is quite dramatic.



Snake River dam counts (Lower Granite and Ice Harbor Dams) indicate that Snake River fall chinook, salmon are also at a very low level of abundance. codedwiretags of Lyon's Ferry Hatchery chinook salmon indicate that interdam mortality is about 28-42% and that overall harvest is about 74%;

In reviewing the status of Columbia River chinook salmon stocks, it is enlightening to examine the history of commercial salmon landings, where data since 1866 are available. Whereas the early landings were entirely from natural spawning stocks, in recent years, a large share of the landings has been from hatchery-produced fish. The number of chinook salmon landed peaked in 1883 at over 2.3 million. Landings decreased to a low of only 58,000 chinook salmon in 1983 (an El Niño year). Although some of this decline in in-river catch can be attributed to increased landings from the ocean fisheries, the depressed condition of these stocks is apparent from drastic reductions in spawning escapements.

Under the Columbia River Basin Fish and Wildlife Program, plans have been proposed to double production of certain chinook salmon stocks. If these plans are successful, catches of chinook salmon could increase significantly.

In 1990, the Sacramento winter-run chinook salmon was listed as threatened under the ESA This stock is in trouble, decreasing from an annual escapement of 35,800 fish in 1971 to only 1,100 in 1992. After receiving a petition from the American Fisheries Society on 5 June 1991 to reclassify the winter run, the NMFS reviewed the status of the run, and on 19 June 1992, it published a proposed rule to reclassify the run as endangered. A final rule is expected any time. The opinion of the NMFS is that since the PFMC has already consulted with the NMFS when the run was listed as threatened, and a "no jeopardy" opinion was issued, upgrading the listing will not place additional constraints on fisheries nor require reinitiation of consulation. When a species is listed as endangered, it could have very severe ramifications not only to salmon management, but to a variety of other agencies associated with the production of salmon.

Other chinook salmon stocks also are seriously depressed. In California, Shasta River chinook salmon (Klamath River system) spawning escapements declined from a peak of 61,800 adults in 1931 to only 541 in 1992. Also, total Klamath River chinook abundance declined following record production in 1988, resulting from a high brood year survival rate, to very low production in 1990 and 1991. In Washington, a number of chinook salmon stocks in Puget Sound have not met escapement goals on a continuing basis in recent years. These stocks include Skagit River spring chinook salmon, Stillaguamish summer-fall chinook salmon and Snohomish summer-fall chinook salmon. Some chinook stocks in southern Oregon, particularly the Rogue River, continue to be depressed.

The other West Coastchinook salmon stocks not specifically mentioned in this report experience annual changes in survival. rates and abundance, but none of the major stocks appear to be in a depressed condition.

CHINOOK SALMON
Pacific Coast
COMMERCIAL AND
RECREATIONAL CATCH
(in 1,000s of fish)

Year	Comm	Rec	Total
1980	1,343	440	1,783
1981	1,247	415	1,662
1982	1,576	479	2,055
1983	712	391	1,103
1984	783	359	1,142
1985	1,044	471	1,515
1986	1,808	464	2,272
1987	2,280	563	2,843
1988	2,736	483	3,219
1989	1,625	492	2,117
1990	1,131	401	1,532
1991	741	328	1,069
1992	573	332	905
Average			
60-90	1,473	507	1,980
90-92	815	354	1,169

Coho salmon produce from 2,400 to 4,500 eggs. After hatching, the fry usually spend their first year in fresh water before migrating to the ocean. Coho salmon typically spend 1 year in the ocean before returning as adults to their home stream to spawn. They average 2.7 to 5.4 kg and up to slightly under 1 m in length at maturity although weights over 11.8 kg have been rewarded

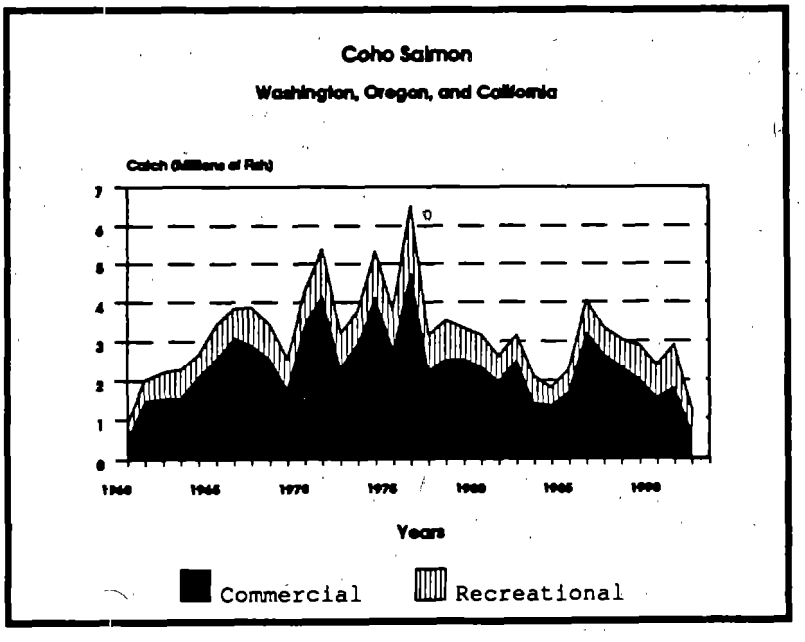
For the period 1960-90, commercial landings of natural and hatchery produced who salmon averaged 2.4 million fish while recreational landings averaged 813,000 fish. For the period 1988-90, commercial catches of coho salmon averaged 2 million fish; while recreational catches averaged 722,000 coho salmon. The ocean catch of coho salmon is limited by annual catch quotas. With some improvement in ocean survival, who salmon should be able to approach the long-term average combined production. To an even greater extent than with chinook salmon, hatchery-produced who salmon have become an increasingly important part of the catch, and in some areas, comprise over 80% of the catch.

Coho salmon landings from the ocean fisheries peaked at over 5 million fish in 1976 and then declined rather drastically to around 1 million or less in recent years. This is in large part due to a shifting of most of the allowable catch from the ocean fisheries to inside fisheries. particularly north of Cape Falcon. This has mainly resulted from Federal Judge Boldt's decision in 1974 relating to Indian fishermen salmon entitlement under treaties signed in the 1850s.

COHO SALMON
Pacific Coast
COMMERCIAL AND
RECREATIONAL CATCH
(In 1,000s of fish)

Year	Comm	Rec	Total
1980	2,344	819	3,163
1981	1,985	646	2,631
1982	2,494	652	3,146
1983	1,417	683	2,100
1984	1,356	449	1,805
1985	1,692	595	2,287
1986	3,207	832	4,039
1987	2,652	695	3,347
1988	2,344	709	3,053
1989	2,020	864	2,884
1990	1,548	838	2,384
1991	1,780	1,123	2,903
1992	632	630	1,262
Average			
60-90	2,418	821	3,239
90-92	1,320	864	2,184

The NMFS was petitioned to list lower Columbia Rier natural coho salmon as endangered under the ESA. In view of the large production of coho salmon from hatcheries on the Columbia River, the management of Columbia River coho salmon has been directed toward harvesting these hatchery fish to prevent wasting large numbers of coho salmon returning in excess of hatchery needs. Consequently, the NMFS declined to list bwer Columbia River coho salmon and stated that native runs, if they persist, will exist only as small remnant populations.



Some other coho salmon stocks have been at low levels of production in recent years and have generally been the constraining stocks under weak stock management. In particular, these are the washington coastal Queets River stock and Hood Canal and Skagit River stocks in Puget Sound In addition. the Stillaguamish who stock and the Oregon coastal natural who salmon stock have failed to meet their escapement goals in recent years. A poor stock abundance predictor has certainly been a factor in these instances.

By Howard W. Braham, Joyce E. Sisson, and Jay Barlow

Thirty-five species of marine mammals reside or seasonally occur in waters along the Pacific continental coast of the U.S. waters (Washington, Oregon. and California). These include whales, dolphins, porpoises, seals, and sea lions. Fourteen of the most commonly observed species 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 mammal species make long-distance migrations or move hundreds of miles within smaller areas of the ocean between seasons of the year. Whales and dolphins often travel from one feeding ground to another or 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 spend the majority of the year in Califomia waters: offshore waters of Washington and Oregon are generally transition areas for animals moving between the southern breeding grounds off Mexico and California, and rich feeding grounds off Alaska. A few species such as the harbor porpoise and

STATUS OF RESIDENT AND SELECTED SPECIES OF MARINE MAMMALS OFF WASHINGTON, OREGON, AND CALIFORNIA. (e)=endangered; (t)=threatened; (d)=depleted.

Species	Abundance (95% C.I.)	Trends (+/-%)	Status and Authority
Gray whale	20,869 (19,200-22,700)	+3.3%/yr (1968-88)	Recovered, ESA
Humpback whales	1,398-2,040	Unknown	Below OSP, ESA (e)
Killer whale (Puget Sound)	146	Stable?	Unknown, MMPA
Delphinid complex[1]	>150,000?	Unknown	Unknown, MMPA
Vaquita	< 100?	Declining	Below OSP,ESA (e)
Harbor porpoise	50,000	Unknown	Uncertain, MMPA
California sea lion	110,000	Increasing	Near OSP, MMPA
Northern sea lion	~5,000	Declining	Below OSP, ESA (t)
Northern fur seal	~6,000	Increasing	Below OSP, MMPA (d)
Harbor seal	75,776	Increasing	MMPA (d)
Elephant seal	73,300	+6.7%/yr (1981-91)	Above MNPL?

[1] Short-finned pilot whale, northern right whale dolphin, bottlenose dolphin, white-sided dolphin, common dolphin, and Grampus, mostly off California.

INCIDENTAL TAKE OF SELECTED MARINE MAMMALS IN DOMESTIC FISHERIES IN WATERS OF WASHINGTON, OREGON, AND CALIFORNIA

Species	Incidental Take (95% C.I)	Fishery (others)	10-year Trend In Take	Impact of Exploitation
Gray whale	tens?	Coastal gill nets	Unknown	Not significant
Delphinid complex[1]	hundreds/year	Coastal set nets and seines	Unknown	Uncertain
Vaquita	~30-40/year	Gill net for shark, totoaba, and shrimp trawls	Increasing	Severe depletion
Harbor porpoise	~100/year	Coastal set nets for halibut and salmon	Increasing?	Possibly vital
California sea lion	3,200/per year (2,000-4,000)	Gill nets for shark, swordfish, and halibut	Increasing	Uncertain
Northern sea lion	Unknown	--	--	--
Northern fur seal	Unknown	--	--	--
Harbor seal	1,400/year (California)	Gill net for shark, swordfish, and halibut	Unknown	Uncertain
Elephant seal	<200/year (California only)	Gill net for shark, swordfish, and halibut	Unknown	Not significant

[1] Shortfin pilot whale, northern right whale dolphin, bottlenose dolphin, whitesided dolphin, common dolphin and Grampus, mostly off California.

Pacific harbor seal are found year-round in Washington and Oregon, but this is also true for these species in California and Alaska. These zoogeographic differences within and between species have led to unique life-history strategic, and result in the need to manage several species, populations or stocks.

Management of marine mammals is carried out under the Marine Mammal protection Act (MMPA) of 1972 and the ESA. Both Acts require that management of marine mammals be based on the identification and enumeration of populations or stocks.

Two species, the vaquita or Gulf of California harbor porpoise and the Guadalupe fur seal, are not endemic to the U. S. (although a few male Guadalupe fur seals do occasionally show up in California). The two species are included in this report because of their rarity and the active conservation efforts carried out on them by the U.S. and Mexican Governments.

A description of the status of selected species, impact of incidental take. and description of individual stocks are presented in the following chapters.

In January 1993, the eastern north Pacific Ocean population of gray whales *(Eschrichtius robustus)* was officially removed from the list of endangered species. In the eastern North Pacific Ocean, gray whales are distributed across the southern Chukchi Sea and northern Bering Sea where they feed from May to November. They migrate from the Bering Sea in late autumn and are-distributed along the lower U.S. West Coast and Baja California between December and March. The peak of the southbound migration passes central California in early January. There is some temporal overlap with the first of the northward migrants leaving Baja California and the tail end of the southward migrants arrive. The northward migration passes central California and Oregon from March to June. In summer and early autumn, gray whale calves are weaned and the incidence of strandings increases.

Gray whales are generally light to dark gray with mottled lighter colored patches from the sloughing of host-specific ectcoparasitic barnacles, *Cryptolepus rhachiainecti.* As with other baleen whales, adult female gray whales reach sexual maturity at slightly greater mean lengths (12.95 m) than do mates (12.43 m). Mean birth length is 4.6 m (both sexes), while mean length at weaning is 7-8 m (usually 6-8 months postpartum) and mean length at 1 year of age is 8 m or greater. -Mean conception date is 5 December and mean birth date is 27 January; gestation lasts 418 days on average. Between 1977 and 1982, nearly 48% of mature females were pregnant. A 2-year birth interval is typical; however, a 3-year calving cycle is not uncommon. Estimated annual survival rates are 95% foradults and 89% for juveniles.

Seventeen surveys have been conducted near Monterey, California, since 1967. The preliminary abundance estimate from the 1987-88 survey was 21,113. The International Whaling Commission's Scientific Committee reexamined the data used to estimate abundance and concluded that a better estimate of abundance was 23,859 (with a 95% confidence interval of 21,500 - 26,500) for this stock of gray whales. These data were reanalyzed by Buckland et al. (1993) giving 20,869 animals as the revised absolute abundance estimates (95% confidence interval: 19,200-22,700). They further estimated the average annual rate of increase between 1967/68 and 1987/88 to be 3.29%. with a standard error of 0.44%.

Between the 1967-68 and 1987-88 southward migrations, the gray whale population increased at about 3% per year. During this same period, the. population was being harvested at a rate of approximately 1% per year. Estimates of abundance prior to the advent of modem whaling and aboriginal exploitation are imprecise and range between 23,000 and 35,000. As of 1988, the eastern North Pacific Ocean gray whale population had recovered to within 20% of its estimated carrying capacity and may have exceeded its 1846 population size, when commercial whaling began.

Although the gray whale is no longer considered in danger of extinction, it will remain subject to harvest prohibitions under the MMPA. The recovery of this population was, in part, due to the'protection provided to the whales on their winter breeding grounds by the Mexican government. Further, as specified in the ESA, populations removed from the listing must be monitored for a minimum of 5 years after delisting. The first of such monitoring surveys for the population was conducted by the NMFS during the southward migration in the winter of 1992-93.

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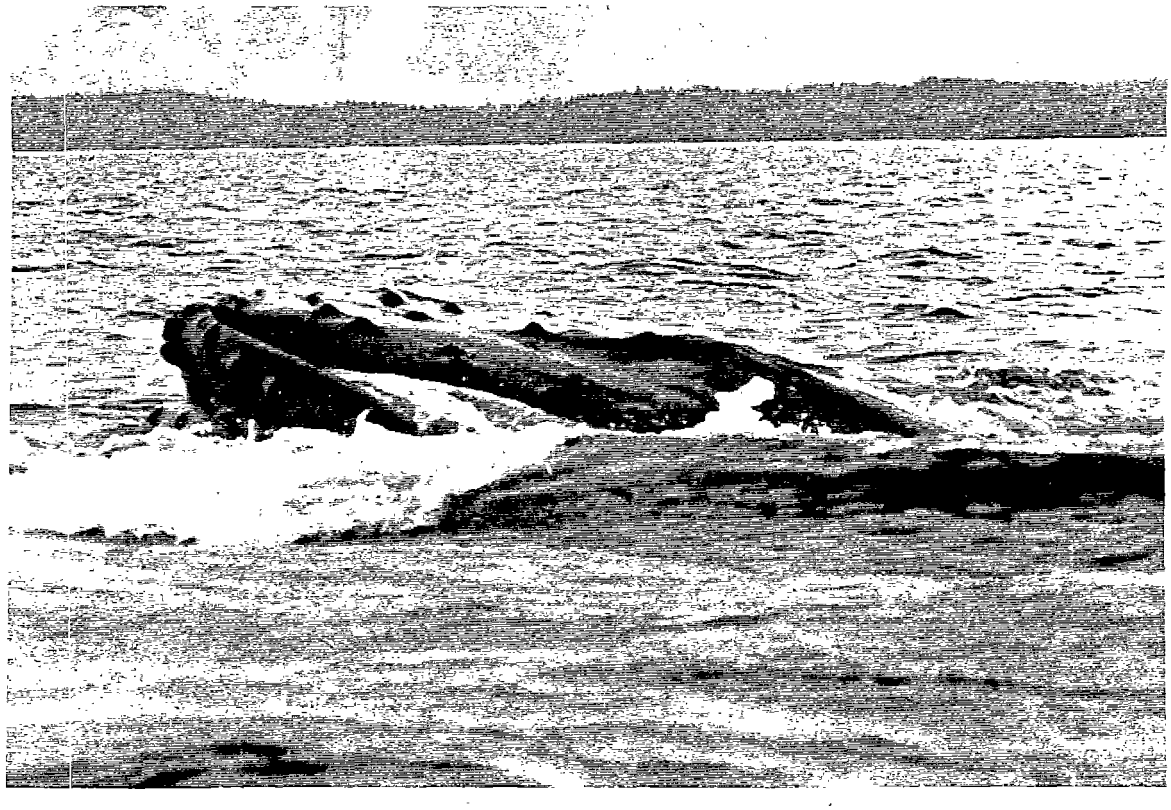

Photo: W.S. Lanton

The North Pacific humpback whale *(Megaptera novaeagliae)* population has been tentatively 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 Ogasawara and Okinawa Islands of Japan). Like most baleen whales, they annually migrate to high-latitude, summer feeding grounds from temperate or subtropical wintering (breeding) grounds. Some exchange takes place between the Mexican and Hawaiian stocks and between the Hawaiian and Japanese stocks.

Humpback whales that give birth and mate in Mexico are believed to spend the summer feeding off of California, principally north of Point Conception. Some have been seen over the continental shelf off Oregon and Washington mainly between March and November. Short-term seasonal distribution patterns have been decumented especially along the central California coast and the Gulf of the Farallones. The paucity of sightings along Oregon and Washington may, in part be due to little survey effort Seasonal distribution of humpback whales on the feeding grounds is subject to variability in oceanographic conditions and the distribution and availability of prey.

The preexploitation population size of humpback whales in the North Pacific Ocean (western and eastern stocks) is not known, but estimates suggest that it may have been on the order of 15,000 whales. There has been no systematic surveys over a long enough period of time to detect trends in abundance.

The current estimate for the eastern North Pacific stock(s) is 1,398-2,040, which is 9-13% of the estimated abundance of humpback whales in the North Pacific Ocean prior to commercial exploitation. More than 1,000 individual whales were identified in Hawaii between 1977 and 1985. Mark-recapture analysis, based on the photo-identification of individuals, has led to an estimate of 1,600-2,100 whales that annually visit Hawaiian waters. The minimum number of humpback whales that frequent

the Gulf of the Farallones, off central California, is on the order of 400 (subject to sampling biases), although the same animals are not sighted each year.

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The killer whale *(Orcinus orca)* is the largest member of the family Delphinidae. 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 is monotypic with geographical variations in size and color. Differences in call repertoires and color patterns may suggest some isolation among pods. Recent studies indicate 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 are more commonly found in colder waters typically within 800 km of major continents. Along the U.S. West Coast, they concentrate near land masses and continental shelf waters, with concentrations noted in Puget Sound, in the adjacent waters of British Columbia, and in Southeast Alaska

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. At least two major types of pods have been noted, Transient pods move in and out of areas typically occupied by resident pods. Resident pods of killer whales are usually found in one area year-round (encompassing several hundred to several thousand square miles) and are dominated by strong matriarchal lineages. The natural mortality rate of killer whales is less than 5% per year and frequently as low as 1%.

Movements of killer whales are believed to be related to the availability of prey, such as spawning salmon, and the movements of seals and whales. They also prey on cod, herring, flatfish, sablefish, and other fish. Killer whales have never been subjected to significant rates of exploitation and are not taken for subsistence. Incidental takes during fishing operations are rare. No significant fishery interactions have been documented in California Oregon, or Washington, although fishermen sometimes shoot at them and use seal bombs and other explosives to keep the whales away from their catch.

In Puget Sound, there are three identified resident pods totaling 91 animals (1992 counts). The largest pod (L) totals 56 animals and the two other pods (J and K) total 19 and 16 animals, respectively. The mininum number of killer whales in California has been estimated to be between 17 and 40 animals. It is anticipated that additional photo-identification work would clarify population boundaries and movement patterns of individuals.

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29 DELPHINID COMPLEX

Dall's porpoise *(Phocoenoides dalli)* are found throughout the North Pacific Ocean and Bering Sea from southern California to Japan. The status and trends of the coastal and pelagic species of dolphins and porpoises in the family Delphinidae are known for only a small number of stocks. A estimate of 1.41 million animals has been made for the entire North Pacific based on data from 1987 and 1990 ship surveys. Using both ship and aerial surveys conducted during 1991, 76,032 Dall's porpoise were estimated to inhabit Californian waters during the summer-fall period The 1992 estimate for Oregon and Washington is 4,799 animals based on aerial survey sightings uncorrected for the number of animals missed due to submergence. Dall's porpoise are taken in a variety of gill-net fisheries and occasionally in trawl fisheries. They are caught principally in coastal set and driftnets, gill-net fisheries in Puget Sound and in the midwater Pacific whiting trawl fishery (mostly between lat. 41°N-46°N) off Oregon and Washington. Additionally, estimates of mortality within the U.S. EEZ for the Japanese high seas salmon fishery for the 1981-87 range between 741 and 4,187 animals. For the five high seas driftnet fisheries in the North Pacific Ocean, the only available estimate of total annual mortality is 3,839 Dall's porpoise for 1990. The high-seas driftnet fisheries have now been banned as a result of the United Nation's Resolution. Even though the incidental mortality of this species has been high, the take has not exceeded a rate of 2% of the population per year. therefore, the population is likely to be within its OSP.

Pacific white-sided dolphins *(Lagenorhynchus obliquidens)* are found throughout the temperate North Pacific Ocean from the waters off Baja California, Mexico, to Japan. They occur year-round off California, Oregon, and Washington, frequenting the continental shelf and slope. On occasion, they form large schools in off shore waters, sometimes in association with other dolphins (e.g., with northern right whale dolphins). Pacific white-sided dolphins are taken in the midwater Pacific whiting trawl fishery and California drift gill-net fisheries and were commonly taken in the experimental shark fishy off the Oregon and Washington coast in 1986-87. In recent years, individuals farther offshore were subject to a relatively high level of mortality in high seas driftnet fisheries, which may have had a negative impact on population abundance (data analysis incomplete). However, these fisheries have been discontinued and the offshore population is expected to recover. There is a seasonal change in abundance of this species within California waters. Based on recent aerial and shipboard survey estimates, 110,398 individuals inhabit California waters during the winter/spring months and 14,766 individuals may be found during summer/fall. Population abundance for Pacific white-sided dolphins for the offshore waters of Oregon and Washington (March through May period) was estimated to be 9,358 (range = 4,613-18,985) with a coefficient of variation (CV) of 37.3% when stratifying the data between slope and offshore waters.

The northern right whale dolphin *(Lissodelphis borealis)* is the only small odontocete in the North Pacific Ocean without a dorsal fin. Two subspecies have been identify, based on color pattern and dental formulas; however the evidence is equivocal. There may be two or more stocks along the California coast based on a hiatus in distribution. A satisfactory evaluation of distinct stocks cannot be made because of the Jack of information on distribution. This species does not appear to be common in the waters of Oregon and Washington based on aerial surveys from 1989 to 1992. N&them right whale dolphins were commonly taken in offshore high seas driftnet fisheries.

Two scenarios are possible in regard to the determination of the status of this species in California: (1) California animals are considered a distinct stock, and (2) California animals are considered to be part of a population continuous with animals in the central North Pacific Ocean, possibly as far west as Japan. In the former case, uncertainties in historical mortality and distribution prevent status determination, and in the latter case the current population is estimated to be between 20 and 90% of its historical size. Thus, no status determination relative to OSP can be made. The apparent decrease in abundance in California could be a true population decrease or could be a shift in distribution to oceanographic parameters, such as water temperature, which can affect prey distribution.

Grampus or Risso's Dolphin *(Grampus griseus)* are distributed worldwide in both tropical and temperate

seas. They appear to be most abundant in the northern areas during warmwater periods. They have not been exploited heavily, but some fakes have occurred in squid purse seine and drifmet fisheries, and in the high-seas driftnet fisheries. Anecdotal evidence suggests that Risso's dolphins may have become more abundant in California during the last two decades, but the apparent increase in sightings may be due to more intensive sampling of the pelagic waters of California. The status of Risso's dolphins relative to OSP is uncertain due to a general lack of available information. However, fishery mortality in the central and eastern North Pacific Ocean has historically been low in relation to estimates of abundance, and it is likely that the population is above OSP. Popularion abundance for Risso's dolphins for the offshore waters of Oregon and Washiigton (March through May period) was estimated to be 7,927 (3,971-15,820) with a CV of 36.4%.

In the North Pacific Ocean, pilot whales *(Globicephala macrorhynchus)* extend from equatorial waters north to Alaska, although sightings north of Point Conception are rare. In southern California, a year-round resident population inhabited the waters near Santa Catalina Island prior to the 1982-83 El Niño, but recent sightings have been rare. This population may have shifted its distribution to the south or west Very little is known about their current distribution patterns. Incidental mortality of pilot whales occurs in the California squid purse seine and driftnet fisheries, in the eastern tropical Pacific tuna purse seine fishery, and in an experimental driftnet fishery for neon flying squid in western Canada Total mortality for 1990 was estimated to be 23 animals; no mortality was observed in 1991.

Common dolphins *(Delphinus delphis)* are often seen in large conspicuous schools. In the eastern Pacific, they are divided into four stocks: northern, central, southern, and Baja neritic. The northern, (short-beaked) and Baja neritic (long-beaked) stocks extend into waters along the coast of California They are rarely encountered in the waters of Oregon and Washington. Recent genetic and morphological information indicates that these two forms are probably diit species. At close range, they can be distinguished by morphological characteristics. Unfortunately, most of the available information on abundance. distribution, and incidental mortality has. not separated the two forms. The peak calving period is spring for the northern stock and early summer for the Baja neritic. Gestation and lactation are 10 and 11 months, respectively. he number of animals in California has increased, but too rapidly to be accounted for by population growth alone. Movement from the south is likely. Based on limited observer coverage, the Califomia gill-net mortality estimate for 1990 was 203 animals and for 1991 was. 373 animals.

Two stocks of bottlenose dolphins *(Tursiops truncatus)* are believed to occur along the coast of California: the coastal form is found within a few miles of the coastline between northern Baja California and central California, the offshore form includes animals more than a few miles offshore, around the southern California islands and farther offshore along the entire California coast. This species commonly associates with other cetaceans and its diet varies considerably depending on local prey availability. Although fishery-related mortality is thought to be low, coastal bottlenose dolphins may be vulnerable to other mortality factors such as pollutants. Pollutants may affect reproduction, immune response, and may make the animals more susceptible to other mortality factors. The low estimates of abundance for the coastal stock, approximately 244 animals, suggests that the take of more than a few animals per year is likely to be unsustainable.

Striped dolphins *(Stenella coeruleoalba)* are a gregarious species found in tropical and warm temperate pelagic waters of all oceans. Prior to 1992, more northerly records of this species in California were rare, but recent surveys show that striped dolphins are more common in California offshore warms than previously suspected. If striped dolphins in California are distinct from the animals in the central North Pacific, then they are expected to be above OSP based on the absence of known fishery mortality in California and the relatively bw levels of mortality experienced in the eastern tropical Pacific Ocean. However, if striped dolphins in California are part of the same stock as the animals taken in the high-seas driftnet fisheries, then the status of this species must be considered uncerain.

Seasonal fluctuations or shifts in the distribution of populations of delphinids have been noted, but why and how these changes occur is unclear. Delphinids, which are highly mobile animals, may have been significantly affected by the El Niño warm water event of 1982-83 because of large shifts in their prey.

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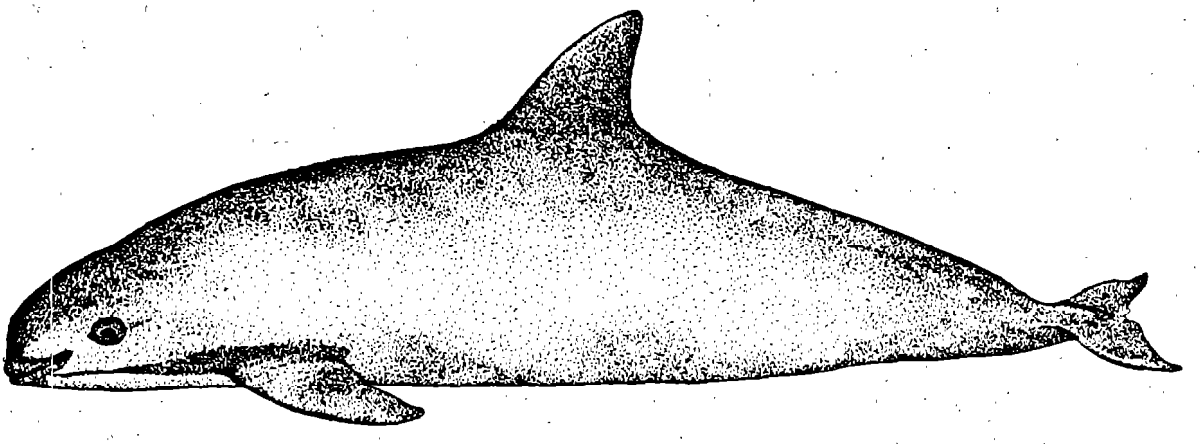

The vaquita *(Phocoena sinus)* has one of the most limited distributions of any marine mammal. This small porpoise is believed to inhabit only the northern regions of the Gulf of California, Mexico. Sparse information about these elusive animals has come from a small number of incidental takes and strandings,. Based on these limited specimens, females appear to be larger than males (150 and 140 cm maximum length, respectively). No other sexual dimorphism has been noted.

Reliable estimates of population abundance do not exist for the vaquita even though several independent expeditions have surveyed the northern Gulf of California in recent years. Rough minimum population estimates are in the range of 50 to 100 individuals. It is assumed that life history parameters of the vaquita are similar to the harbor porpoise *(Phocoena phocoena)*. That is, female maturation probably occurs at 3-5 years of age, mating takes place in late summer, calving occurs in spring to early summer. lactation lasts for approximately 8 months, and the average calving interval is greater than 1 year. The vaquita is probably a short-lived animal, possibly 13-15 years. Population growth rates have been estimated based on ranges of values for reproduction and mortality rates. With a maximum growth rate less than 10% per year, only a few new individuals may be added to the population each year.

The vaquita is vulnerable to incidental mortality in commercial fishery operations in the Gulf of California Historically, this species has been taken in the gill-net fisheries for totoaba *(Totoaba macdonaldi)* and for shark, and in shrimp trawls. It has been estimated that the incidental kill was in the range of tens to hundreds of vaquita per year in the early 1970s.

The Mexican government closed the totoaba fishery in 1975 as a result of marked declines in the totoaba stock(s). Totoaba may still be in danger of extinction; however, fishermen in the northern Gulf of California claim that stock levels have recovered and

VAQUITA
Gulf of California

Estimated annual incidental mortality	= ~ 30-40
Current stock size estimate	= 100-500
Fisheries involved	= Totoaba & shark gill net shrimp trawl
Management	= CITES; listed as endangered under ESA; protected by Mexican law
Status of exploitation	= Incidental take in fisheries; no direct take
Age at sexual maturity	= 3-5 years
Length at sexual maturity	= 130 cm
Assessment approach	= Minimum population estimation and trends in abundance needed. Status relative to maximum abundance of little importance at this time.

that this fishery should be reopened. Two consecutive years of experimental totoaba fishing operations during the 1980s resulted in the incidental take of 14 vaquita in gill nets near El Golfo de Santa Clara, Sonora, Mexico. From interviews with fishermen. it was estimated that about 32 vaquita were killed annually until 1992. In that year, increased surveyance by the Mexican Navy Patrol has reduced that number, but exact levels of take for each fishery are still unknown

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31. HARBOR PORPOISE

The harbor porpoise *(Phocoena phocoena)* is a common inhabitant of nearshore areas along the U.S. West Coast. Preliminary results of genetic stock identification research indicates that some gene flow does exist among harbor porpoise occupying California. Oregon, and outer coastal Washington waters. The inland marine waters of Washington, from the Strait of Juan de Fuca and Puget Sound north to southern British Columbia, are currently being studied to determine if separate stocks exist there. In California, harbor porpoise are found only north of Point Conception and appear to be most abundant near the mouths of large rivers, harbors, and bays. For management purposes, the animals inhabiting central California are treated as a separate stock in an effort to prevent local depletion by fisheries using gill nets.

The harbor porpoise one of the smallest of all cetaceans, reaching maximum lengths of about 1.8 m and maximum weights of about 90 kg. Adult females are slightly larger than adult mates. Harbor porpoise may travel in groups of up to 10 animals, although they often appear solitary when seen in the wild. They prey on cephalods and favor schooling nonspiny fish like herring, smelt, mackerel, sardines, pollock, and whiting. Harbor porpoise are in turn preyed upon by sharks and killer whales. Calves are born during summer (May-July) after an 11 -month gestation. calving intervals are approximately 2 years.

Annaul surveys to monitor abundance of harbor porpoise have been conducted by the california Department of Fish and Game and NMFS since 1984. These surveys have shown that the primary concentration along the West Coast is the mouth of the Columbia River with secondary concentrations along the coasts of Oregon and Washington. For Oregon and southern Washington, the abundance estimate is approximately 24,000 basal on combined aerial and shipboard surveys. In contrast, harbor porpoise abundance is much lower along the northern Washington coast and within the Straits of Juan de Fuca and the waters surrounding the San Juan Islands. In these lower density areas the abundance estimate is approximately 3,900. Although common in the 1940s, there are now very few harbor porpoise in Puget Sound, Washington. The most recent analysis estimates that there are 13,900 harbor porpoise in California including the 3,810 animals that make up the central California stock. Using data through 1991, the central California stock is estimated at 30-97% of its carrying capacity. There is no evidence of population increase or decrease along the West Coast. Analyses of existing data suggest that a minimum of five additional survey years would be needed to detect a 5-10% annual change in abundance.

The rate of incidental mortality of harbor porpoise in gill nets in California from 1983 to 1988 was estimated at 200-300 per year, all from central California Because of recent restrictions on gill-net fisheries along the California coast, the current rate of mortality is estimated to be less than 100 per year. The total incidental take of harbor porpoise in Oregon and Washington is unknown. However, in 1988, over 100 harbor porpoises were taken incidental to the northern Washington marine set-net fishery

HARBOR PORPOISE
Pacific Coast

Estimated annual incidental mortality:		
	- California	= <100
	- Washington	= Unknown
Stock size -	California (1990)	= 13,900
	- Oregon and southern Washington (1991)	= 24,000
	- Washington inland waters (1991)	= 3,900
Fisheries involved -	California	= Halibut set-net fishery
	- Washington	= Salmon set-net fishery
Management		= As required under MMPA
Status of exploitation		= > 30% of K
Age at sexual maturity		= 4 years
Length at sexual maturity		= 150 cm
Assessment approach		= Back calculation

for salmon along the outer north shores of Washington. Because of reduced fishing effort the the level declined in this gill-net fishery to 2 in 1992. Possibly high levels of incidental takes are suspected in gill-net fisheries around the San Juan Islands and British Columbia, Canada

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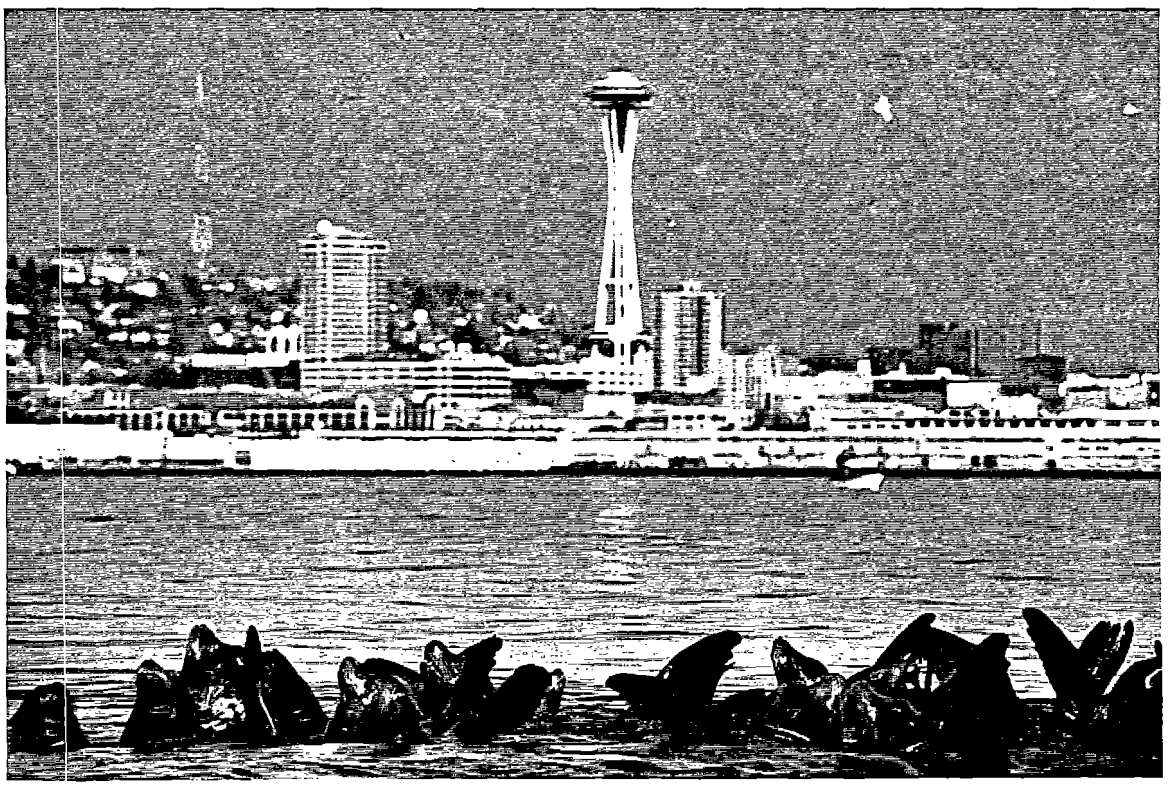

Photo: Patrick Gearin

The California sea lion *(Zalophus californianus californianus)* is found from the Tres Marias Islands, Mexico to British Columbii and is comprised of three stocks: the U.S. stock, the western Baja California stock, and the Gulf of California stock. Pupping and mating take place mainly on the Channel Islands, California and on islands off the Pacific coast of Baja California, Mexico, from late May to late July. The pups are weaned from 8 months to a year or more. Researchers are uncertain about the age at sexual maturity for either males or females. Adult males can weigh over 400 kg and reach 2.6 m in length. They can be readily distinguished from females by a bony flange on the head called a sagittal crest which develops during puberty. Females weigh about 100 kg and reach 2.0 m in length.

In 1990, there were approximately 26,704 California sea lion pups counted on U.S. rookeries. This count multiplied by the pre-census mortality figure of 15% represents about 30,709 live births. The total U.S. population is greater than 110,000 animals and has been growing at an annual rate of 10.2% recently. Although the pre-exploitation population size is unknown, recent studies suggest that its present abundance may be higher than any historical level.

An abundance estimate for the western Baja California stock, which appears stable, was about 74,467 individuals for 1990. The Gulf of California stock abundance was estimated at 22,620-24,520 in 1986 when most rookeries and haul outs were censused.

Food habit studies indicate that California sea lions take a variety of prey. Their main diet consists of pacific whiting, rockfish, anchovies, mackerel, walleye pollock, dogfish sharks, market squid, and octopus. During the 1982-83 El Niño event, pelagic red crabs were also found to be a source of food for sea lions in California.

The California sea lion is the best known and most often seen of the West Coast pinnipeds. In

recent years, they have gained notoriety for taking over portions of marinas in Monterey Bay and San Francisco Bay, and for threatening the viability of a native run of steelhead trout *(Oncorhynchus mykiss)* near the Hiram M. Chittenden Locks in Seattle, washington. califomia sea lions are reported to consume tons of valuable fish, to destroy fishing gear, and to interfere with fishing operations. Fishermen and some resource managers, faced with increasing fishery interactions, believe that sea lion populations have grown to a point where nuisance animals should be eliminated. An estimated 2,000-4,000 califomia sea lions are incidentally taken annually in gill-net fishing operations in California. Tag returns from Mexican fishermen indicate that California sea lions are incidentally killed in Mexico as well, but the level of take has not been quantified. In addition, a small number of sea lions are taken in Oregon, Washington, and British Columbia, Canada; these are predominantly males.

CALIFORNIA SEA LION
Pacific Coast

Incidental mortality (1991, U.S.)	= 1,865
Stock size (1991)	= >110,000
Fisheries involved	= Gill net fisheries for shark, swordfish and halibut
Management	= As required under MMPA
Status of exploitation	= Lower end of optimum sustainable population range
Age at sexual maturity	= Females: 4-5 years Males: 7-9 years
Length at sexual maturity	= Females: 1.8 m Males: 2.4 m
Assessment approach	= Dynamic response method

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California Sea Lion Pup Counts
U.S. Channel Islands

Year	Number	Year	Number
1975	12,039	1984	13,732
1976	11,893	1985	15,438
1977	11,589	1986	18,014
1978	12,732	1987	19,297
1979	14,449	1988	19,710
1980	14,393	1989	23,644
1981	16,941	1990	25,292
1982	19,412	1991	N.A.
1983	12,567	1992	22,433

The northern sea lion *(Eumetopias jubatus),* also known as Steller's sea lion, is endemic to the North Pacific Ocean. Its range is from California to the Kuril Islands, Russia, and north to lat. 63°N in the Bering Sea. About 50 breeding rookeries occur throughout the species range except in Washington. Sea lions exhibit strong site fidelity, and many disperse widely after reproduction. Pupping peaks in mid-June. and lactation lasts 3 months to over 1 year. Sexual maturity occurs at age 3-6 years of age in females; gestation lasts 9 months after 3 months of delayed implantation. Adult males are territorial and the mating system is polygynous.

In Alaska, northern sea lions feed on groundfish (such as walleye pollock), salmon, squid, herring, and other fin-fish species. Summer feeding trips by lactating females extend out to at least 20 nmi; in winter they may forage out to several hundred nautical miles. Their feeding behavior off the West Coast is not well understood.

The northern sea lion population was first noticed to be declining in 1976. Since the late 1960s, the species has declined by about 70%. principally in Alaska. Within Alaska, the northern sea lion trend site population declined from 116,804 counted in 1979 to 34,844 in 1992. The greatest decline since the 1970s has been in the central Aleutian Islands (83% decline). During the 1980s, all areas of the species' range declined except between Southeast Alaska and Oregon; in California, they have been gradually declining since the 1950s. Present abundance in Washington, Oregon. and California is about 5,000.

Northern sea lions are the marine mammal most frequently taken in trawl fisheries in Alaska. The reported take in 1992 was less than 30. Incidental take in foreign trawl fisheries and joint venture walleye pollock roe fisheries in the 1970s and early 1980s may have contributed to the sea lion's decline. The impact of incidental take on northern sea lions in Washington, Oregon, and California is minor.

It is unclear why the decline in northern sea lions has occurred and whether it is directly or indirectly related to commercial fishing activities, disease, or from some unknown natural environmental factors. Other factors such as redistribution, predation, native subsistence, and entanglement in nets and debris apparently are not significant in the decline. Intentional shooting may have been important at various times or 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 certain commercial fishing activities near sea lion breeding sites and habitat potentially important for feeding across much of the southern Bering Sea and Gulf of Alaska. No specific areas along the West Coast are currently proposed for additional protection; however, Oregon has imposed limits on some commercial fishing around Oregon sea lion rookeries:

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Photo: Bruce Robson

The northern fur seal (Callorhinus ursinus) is a monotypic genus ranging across the subarctic waters of the North Pacific Ocean to the temperate waters of the U.S. West Coast. A breeding population is also found on San Miguel Island, California.

Some northern fur seals are found throughout their range in the eastern North Pacific Ocean in nearly all months of the year with periods of peak abundance varying by time and area. Many immature seals of both sexes remain at sea during the first year or two of life and do not return to their island of birth until ages 2 or 3. Most fur seals spend about half the year at sea (November through May-June) and the remainder (July-October) on and around their home islands during the breeding season. Fur seals are most frequently seen from about 70 to 130 km from land and in greatest numbers along the continental shelf and slope primarily because of abundant food resources in this area. 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). Older males (10-15 years) from the Pribilof Islands winter farther north in the North Pacific Ocean than younger males and females. Females and young males appear along the continental shelf during their southbound migration from about lat. 57° to 46°N in late November and off California (lat. 40° to 38°N) in late December. In January-April, major concentrations occur between California and British Columbia. The northward migration begins'by March; some seals follow the continental shelf north, then travel west through the Gulf of Alaska and into the Bering Sea through passes in the eastern Aleutian Islands. Limited tag sightings suggest that fur seals from San Miguel Island, California move north after the mating season and probably intermingle with their northern counterparts to feed in the eastern North Pacific Ocean.

The estimated total number of northern fur seals in the North Pacific Ocean in 1983 was 1.2 million. The population on the Pribilof Islands in 1992 was 982,000; this level is significantly less than observed in the 1950s when the population had reached its highest population size this century. The current population size on San Miguel Island is approximately 6,000. It increased steadily beginning in the late 1960s, when tile island was colonized until 1981. Between 1982 and 1984 the population on San Miguel Island declined approximately 60% (as measured by pup production), most likely a result of the impact of the 1982-83 El Niño event. This warmwater event acted the distribution of fur seal prey in California prey causing emigration or increased mortality of adults and juveniles at sea after the breeding season and likely the starvation of weaned pups born in 1983. Pup production has returned to its pre-El Niño levels since 1985.

In 1991, 430 northern fur seals were taken incidentally in the high-seas gill-net fisheries for squid and salmon (based on 4,763 observed net retrievals). The North Pacific high-seas driftnet fisheries were discontinued at the end of 1992. Northern fur seals are also occasionally taken in domestic trawl and other net fisheries. In 1990, only two northern fur seals were reported taken alive in trawl nets in the domestic groundfish fisheries in Alaska and none were observed taken in 1989. The take in Washington, Oregon, and California is unknown but probably negligible.

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35 HARBOR SEAL

The Pacific habor seal *(Phoca vitulina richardsi)* occurs throughout the eastern North Pacific Ocean from the outer coast of Baja California (Cedros Island) north to the eastern Bering Sea. Along the U.S. West coast, three stocks are recognized for management purposes: 1) inland waters of Washington state, 2) outer coast of Washington and Oregon, and 3) coastal California Adult males reach lengths of 1.62 m and weigh about 113 kg. Adult females are slightly smaller. The coloration pattern of adults is quite variable, but all have dark spots on light pelage or light spots on dark.

The breeding season (mating and pupping) varies with latitude along the coast, occurring in March-April on the Channel Islands of southern California, and later with an increase in latitude. In Puget Sound, pups are born from July to October in the south end of the Sound, whereas in the north end of the sound pups are born June to August. In Hood Canal, pupping extends from August to December.

Pups are born at approximately 82 cm in length and weigh about 10 kg. They are weaned at 4 to 6 weeks and weigh about 24 kg. Adult females ovulate and mate at the end of weaning with a 2-month delayed implantation. sexual maturity occurs at 3-4 years of age for females and 5 years for males. Their diet consists of fish and cephalopods--in particular, flounder, herring, tomcod, hake, salmon, lamprey, and squid.

The harbor seal population along the West Coast is increasing. Concurrently, the number of haul outs occupied has also increased. The 1992 mainland California count was 18,700 seals, and a count at the eight Channel Islands was 4,433 seals. Combining these counts produces a minimum population estimate for the California stock of 23,113. Using the correction factor of 1.4 to 2 suggested by Boveng (1988) to account for unobserved seals in the water, the total California population of harbor seals is estimated to be between 32,386 and 46,266.

The estimated abundance of the Washington and Oregon coastal stock is 27,579-30,539 seals. The abundance for the stock in the inland waters of Washington is 13,549-15,367 harbor seals. These estimates are based on counts in 1992 and correction factors developed using radio tagging experiments. Harbor seals in Washington and Oregon have increased 68% annually between 1983 and 1991.

From recent analysis, there is no firm evidence to suggest that any of the stocks are above their maximum net productivity level. The occurrence of the 1982-83 El Niño event and the possibility that incidental fishery mortality has increased may have affected the population dynamics of the California stock It is likely that the survival and reproduction of harbor seals were altered during the El Niño event and that some of the effects persisted for several years after 1983. In addition, the gill-net fishery effort has increased substantially in California and Washington since the late 1970s. No OSP determination has been made for any harbor seal stocks.

HARBOR SEAL
Pacific Coast

Annual incidental mortality (1991)	= ~1,300
Stock size in California (1991)	= 32,325
Coastal Washington and Oregon (1992)	= 29,021
Inland waters of Washington (1992)	= 14,430
Fisheries involved	= Gill-net fisheries for halibut, salmon, shark and swordfish
Management	= As required under MMPA
Status of exploitation	= Near maximum net productivity level (recovering)
Age at sexual maturity	= Females: 2-5 years Males: 3-6 years
Assessment approach	= Dynamic response method

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Counts of Harbor Seals in California from CDF&G Aerial Photographic Surveys off the California Mainland and Islands

Year	Mainland	Island	Total
1982	12,776	-	-
1983	10,945	-	-
1984	10,946	3,218	14,164
1985	12,598	2,280	14,878
1986	13,831	1,801	15,632
1987	15,124	4,322	19,446
1988	14,095	3,947	18,042
1989	16,034	4,279	20,313
1990	15,675	2,808	18,483
1991	18,346	4,743	23,089
1992	18,700	4,433	23,133

Photo: AFSC

The northern elephant seal *(Mirounga angustirostris)* is the largest pinniped in the Northern Hemisphere. Adult males reach lengths of greater than 4.5 m and weigh on average about 1,800-2,000 kg. Females reach lengths of 3.4 m and weigh about 907 kg. The male develops a large, bulbous trunklike snout, from which it gets its common name. Breeding colonies are found on San Miguel Island, Santa Barbara Island, San Nicolas Island, Año Nuevo Island, the South Farallon Islands, several areas along the coast of California, and on islands off the Pacific side of Baja California, Mexico. Two pups were born in Oregon in 1993. The pupping and mating season is from December through March. Gestation lasts about 9 months in addition to delayed implantation of about 2 months. Pups are weaned by 4 weeks, but remain on the rookery for another 8-10 weeks, sleeping during the day and gradually beginning to enter the water at night. Departure from the rookery by the pup occurs at approximately 3 months of age. About 15% of females begin to mate at 2 years of age, whereas males reach sexual maturity at age 5. Most young males (5+ years) are prevented from mating by larger, older bulls until the younger seals are at least 8-9 years old; maximum age is probably about age 14 for males and about 20 for females.

Experiments using time-depth recorders show, that adult male elephant seals can dive for up to an hour at a time to a maximum depth of 1,500 m. During the 2-5 months at sea, adults dive continuously and remain on the surface to rest for only 4 minutes between dives. Adult males and females are segregated at sea Male elephant seals migrate from California to the Gulf of Alaska and the eastern Aleutian Islands, a distance of at least 4,700 km, twice each year. Adult females from southern California forage westward along the North Pacific Ocean transition zone located between 40° and 45°N twice each year for about 2.5 and 7 months. Stomach content analyses indicate that just before returning to the California Channel Islands, elephant

NORTHERN ELEPHANT SEAL
Pacific Coast

Average annual incidental mortality	= 200
Stock size (1991)	= 73,300
Fisheries involved	= Gill-net fisheries for halibut, shark and swordfish
Management	= As required under MMPA
Status of exploitation	= Near maximum net productivity level (recovering)
Age at sexual maturity	= Females: 2-5 years; Males: 5-7 years
Length at sexual maturity	= Females: 3.4 m; Males: 4.6 m
Assessment approach	= Dynamic response method

seals feed on squid, small sharks, rays, ratfish, rockfish, and Pacific whiting. They probably feed on squid and mesopelagic fish while art sea

The exploitation and subsequent recovery of the northern elephant seal population is one of the great success stories of a species near extinction. Biologists estimate that only 100-500 elephant seals were left on Guadalupe Island, Baja California, Mexico, at the low point of their abundance this century before protective legislation was passed. The entire current population may have originated from this small group of animals. Based on pup counts, the current U.S. population now exceeds 73,300 animals. The apparent growth rate since 1981 has been about 6.7% annually. Annual surveys indicate that this species tire occupied most or all of its historical rookeries and hauling grounds. Dynamic response analysis of the 1964-1991 time series of births suggests that the population may be above its maximum net productivity level and may therefore be within the range of an OSP, but these results are preliminary and should be viewed with caution.

Elephant seals have been taken in both driftnet and set-net fisheries. In the early 1980s, it was estimated that 25 animals per year were taken in southern California Current data suggest a higher level of lethal entanglement is occurring than previously estimated. The total incidental mortality associated with U.S. gill net fishing operations was estimated at 137 seals in 1991.

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