Pacific Coast and Alaska Pelagic Fisheries

Anne Allen, SWFSC

Unit 14

KEVIN T. HILL
E. DORVAL
PAUL R. CRONE
JENNY D. MCDANIEL

NMFS Southwest Fisheries Science Center

La Jolla, CA

MARCI L. YAREMKO
DALE SWEETNAM

California Department of Fish and Game

Santa Barbara, CA

DOUGLAS A. WOODBY
MIKE PLOTNICK

Alaska Department of Fish and Game

Juneau, AK

Photo above:
Close-up view of a California market squid.

INTRODUCTION

Several stocks of coastal pelagic species (CPS) support fisheries along the Pacific Coast from northern Mexico to Alaska. The major ones are Pacific sardine, northern anchovy, Pacific chub mackerel), jack mackerel, California market squid, and Pacific herring. Sardine, anchovy, and the two mackerels are primarily concentrated and harvested off California and Baja California, although a major sardine fishery has recently developed off the Pacific Northwest. Market squid are distributed from the Pacific Northwest to Baja California, Mexico, but the population is mostly harvested in northern and southern California. Pacific herring are taken along the West Coast from California to Alaska.

Sardine and anchovy are the most prominent of the CPS fisheries from a historical perspective. These small pelagic fish, like Peruvian anchovy and Japanese sardine, tend to fluctuate widely in abundance from year to year. California sardines supported the largest fishery in the western hemisphere during the 1930's and early 1940's, when total annual catches averaged 500,000 metric tons (t). Sardine abundance and catches declined after World War II, and the stock finally collapsed in the late 1950's. In the mid 1940's, U.S. processors began canning anchovy as a substitute for sardine. Consumer demand for canned anchovy, however, was low, and catches from the mid 1940's to mid 1950's averaged only 20,000 t per year. Catches declined and remained low before starting to increase in 1965 after the sardine collapse. Together with catches from Mexico, the total catch increased

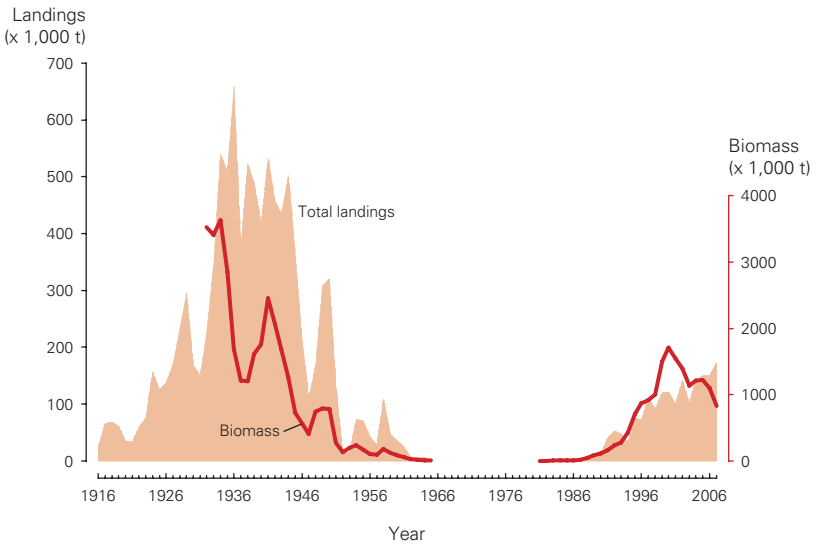

Figure 14-1
Pacific sardine landings and biomass in metric tons (t), 1916–2007. No data are available for 1966–80, when the biomass had declined to immeasurable low levels.

to 250,000 t per year during 1975–80. Thereafter, U.S. catches declined mainly due to significant price reductions for fishmeal. Low prices and market problems continue to prevent a significant U.S. reduction fishery for anchovy in recent years. The other small pelagic species also have a tendency to fluctuate widely in abundance.

All of these pelagic fishery resources are under state or Federal management. The fisheries for Pacific sardine, northern anchovy, Pacific chub mackerel, and jack mackerel are managed under the CPS Fisheries Management Plan (FMP) by the Pacific Fishery Management Council; California market squid are monitored under this FMP as well, but management has been transferred to the State of California. The State of California also manages the Pacific herring fishery in the waters off California. The State of Alaska manages its inshore Pacific herring fishery.

The wellbeing of ecologically related species in the marine ecosystem is an important factor in management of CPS resources. For example, the endangered brown pelican depends on anchovy as an important food source. Thus, the CPS FMP has specified a threshold for its optimum-yield determination to prevent severe depletion and provide adequate forage for marine fishes, mammals, and birds.


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Dense schools of anchovy seen from the coast of southern California.

PACIFIC COAST PELAGIC FISHERIES

Pacific Sardine

California's Pacific sardine abundance has gone through multiple boom-and-bust cycles (Figure 14-1). The decline of the resource, from a biomass of more than 3.6 million t in the 1930's to immeasurably low levels (a few thousand t) in the 1970's, stimulated much debate as to whether fishing or an adverse natural environmental period was to blame. In retrospect, the intense fishing pressure on the resource in the 1930's and 1940's probably accelerated a long-term pattern of natural decline. The biomass of sardines remained negligibly low for about 40 years. Stock biomass increased rapidly through the 1980's and 1990's, peaking at 1.71 million t in 2000, but has since decreased to 832,706 t in July 2007 (Hill et al., 2007).

In the past, sardines were harvested for fishmeal, bait, and human consumption. However, there is currently no fishmeal (reduction) fishery. Sardines are now taken for human consumption, bait, and aquaculture feed. Commercial demand for sardines is strong and, as resource abundance has grown, the coastwide fishery has revived. Recent average yields (2005–07) for the United States are 105,667 t per year and 157,573 t for combined fisheries of Pacific North America (Table 14-1). The current U.S. yield is 135,946 t, or about 77% of the maximum sustainable yield for the U.S. fishery. However, the most recent stock assessment indicated a decline in abundance and resulted in a significantly lower harvest guideline for 2008 (Hill et al., 2007).

Northern Anchovy

Northern anchovy, fished off California and Mexico, are divided into several subpopulations. The central subpopulation of the resource is the one that supports most of the U.S. fisheries. Historically, anchovy have been harvested for reduction into fishmeal, oil, and soluble protein products. Other uses include human consumption (fresh, frozen, canned, and paste), and as bait (live and frozen) for recreational fisheries.

Anchovy landings in California have fluctuated more in response to market conditions than

Species/stock	Recent average yield (RAY)[1]	Current yield (CY)	Sustainable yield (MSY)	Stock level relative to B_{MSY}	Harvest rate	Stock status
Pacific Coast						
California market squid[2]	51,458	Unknown	Unknown	Unknown	Unknown	Unknown
Jack mackerel[3]	705	646	48,000	Unknown	Not overfishing	Undefined
Northern anchovy[4]	14,946	13,297	31,000	Unknown		
Pacific herring[5]	85	34	Unknown	Unknown		
Pacific chub mackerel[6]	13,657	16,623	102,327	Above	Not overfishing	Not overfished
Pacific sardine[7]	157,573	173,119	175,361	Above	Not overfishing	Not overfished
Subtotal, Pacific Coast	238,424	255,177	408,180			
Alaska						
Pacific herring (Bering Sea)[8]	23,541	Unknown	Unknown	Near		
Pacific herring (Gulf of Alaska)[8]	17,212	Unknown	Unknown	Near		
Subtotal, Alaska	40,753	40,753	40,753			
Total	279,177	295,930	448,933			
U.S. subtotal	216,742	207,232	372,438			

Table 14-1
Productivity in metric tons (t) and status of Pacific Coast and Alaska pelagic fisheries resources.

[1]2004–06 coastwide average, unless otherwise noted.

[2]Currently, California market squid are managed based on an egg escapement model, which evaluates the interaction between the population's reproductive output and levels of fishing pressure. This assessment approach does not provide estimates of historical or current total biomass, so a definitive yield (e.g. quota, CY, MSY, etc.) cannot be determined at this time. Values are the U.S. share only.

[3]RAY and CY are 2005–07, U.S. share only. MSY is a crude coastwide estimate calculated using 1995 data.

[4]RAY and CY are 2005–07; the U.S. share of the RAY is 11,641 t. Status determinations are based on two subpopulations and are not available for the coastwide stock. The central subpopulation is not overfishing and has undefined stock status; the northern subpopulation has undefined harvest rate and stock status.

[5]RAY is 2000–02, U.S. share only. Harvest rate and stock status determinations are not available for this stock.

[6]U.S. share of the RAY is 6,433 t.

[7]RAY and CY are 2005–07; the U.S. share of the RAY is 105,667 t.

[8]Harvest rate and stock status are not available for this stock.

to stock abundance. Figure 14-2 shows the historical catch trend for the United States and Mexico. Landings by the United States have varied from 1,000 t to nearly 160,000 t. Since 1983, U.S. landings have been low, and have been used mostly for live bait and other non-reduction uses. The biomass trend for the anchovy resource (Figure 14-2) hit a peak of 1.6 million t in 1973 and declined steadily to 392,000 t by 1994. The anchovy resource, last assessed in 1995 (Jacobson et al., 1995), is assumed to be at a moderate level of abundance. The default acceptable biological catch (ABC) for the United States is 25,000 t or 30% of the maximum sustainable yield (Table 14-1). Recent catches have been much lower (about 11,000 t) due to a lack of commercial markets.

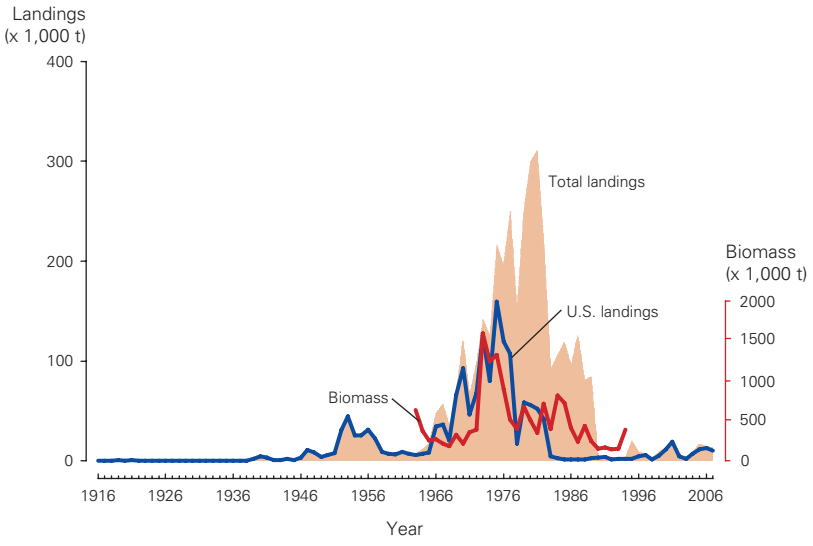


Figure 14-2
Northern anchovy landings and biomass in metric tons (t), 1916–2007.

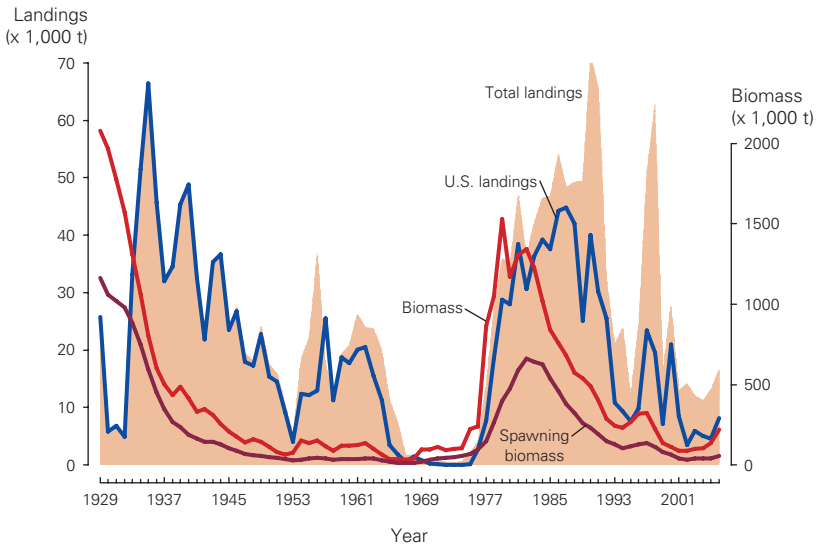


Figure 14-3
Pacific chub mackerel landings and biomass in metric tons (t), 1929–2006.

Pacific Chub Mackerel

Pacific chub mackerel has a worldwide distribution in temperate and subtropical seas. On the Pacific Coast, it is most abundant south of Point Conception, California. Pacific chub mackerel supported one of California's major fisheries during the 1930's and 1940's and again in the 1980's and 1990's. It was second only to sardine during the heyday of the southern California sardine fisheries in the 1930's and 1940's. The peak catch in that era was 66,600 t in 1935, and catches generally declined throughout the 1940's and 1950's before reaching a low in the mid 1960's and early 1970's (Figure 14-3). In 1970, a moratorium was placed on the fishery after the stock collapsed.

A series of successful year-classes in the late 1970's stimulated a recovery of the stock, and the fishery was reopened under a quota system in 1977. Three separate fisheries now harvest the resource: the California commercial fishery, a sport fishery, and a Mexican commercial fishery. From 1980–89, the California recreational catch averaged 1,500 t per year. The combined fisheries of the United States and Mexico landed 71,551 t in 1990 and 62,823 t in 1998 (Figure 14-3). A harvest guideline of about 40,000 t currently restricts the U.S. commercial catch (Dorval et al., 2008), but the recent average yield has been only 6,400 t (Table 14-1). If the biomass dips below 18,200 t, commercial fishing will be stopped.

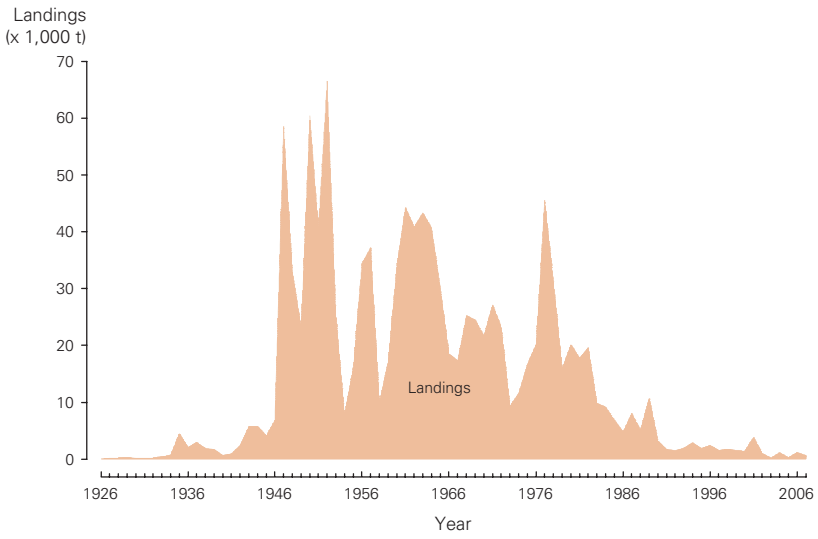
The historical trend in Pacific chub mackerel biomass is shown in Figure 14-3. Recent peak abundance was 1.34 million t in 1982. Biomass declined to a recent low of about 90,000 t in 2001 and since then has risen to a recent average of about 280,000 t. Analyses of fish-scale deposits in ocean bottom sediments off southern California and Baja California indicate that the prolonged period of high Pacific chub mackerel biomass levels during the late 1970's and 1980's may have been unusual and would only be expected to occur, on average, about once every 60 years.

Jack Mackerel

Jack mackerel catches have fluctuated widely with changing market demands and the ability of the fleet to fish for other species that were more valuable or available, especially sardine, Pacific chub mackerel, and California market squid. Additionally, the availability of jack mackerel can be very erratic. Jack mackerel has two distinct behavior patterns during its life cycle: juveniles are found inshore off southern California and Baja California, while adult fish are distributed offshore and farther north, as far as the Gulf of Alaska in some years. Adult jack mackerel found offshore are sometimes caught incidentally by trawlers, particularly those targeting Pacific hake.

The foreign trawl fishery of the 1970's resulted in jack mackerel being placed in the groundfish FMP. Jack mackerel are now managed under the CPS FMP and have a default ABC for the United States of 31,000 t per year. The history of jack mackerel commercial landings is shown in Figure 14-4. Landings for the U.S. fishery peaked at 66,500 t in 1952. Recent average yield for the U.S. is only about 705 t (Table 14-1). Jack mackerel have occasionally been important to the recreational fishery off southern California.

Assessment and management of jack mackerel are difficult because of limited data and broad distribution of the species. The most recent estimate of biomass was made in 1983. Spawning biomass was estimated at 1.5 million t and total biomass was estimated at 1.6–1.9 million t. Its maximum sustainable yield is little more than an educated guess at this time (Table 14-1).

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Jack mackerel larvae.

Figure 14-4
Landings in metric tons (t) of jack mackerel in the United States, 1926–2007.

California Market Squid

California market squid range from southeastern Alaska to Bahia Asunción, Baja California, Mexico, and play an important role in the food web of many organisms along California's coast. Market squid are mollusks and members of the Family Loliginidae. This species is milky white to iridescent in color and, like most squid species, has eight arms and two feeding tentacles. Adults caught in the fishery average 130 mm dorsal mantle length and are believed to live roughly 6–8 months, dying within days following spawning (Macewicz et al., 2004). Distinguished by its high productivity, the California market squid fishery fluctuates in response to environmental conditions, coupled with rapid changes in the export market (Figure 14-5). With significant expansion of fishing activity in southern California waters during the 1980's and 1990's, the California market squid fishery has emerged as one of the most important in the state in terms of revenue and tons landed.

The California market squid fishery was an unregulated, open-access fishery before 1 April 1998. In order to ensure sustainability of the resource, new legislation placed a moratorium on the number of vessels in the fishery. In 2001, legislation transferred authority for management of the market squid fishery to the California Fish and Game Commission. In compliance with this legislation, the California Department of Fish and Game (CDFG) adopted the Market Squid FMP in 2005, with implementation of the management recommendations for the 2005–06 fishing season.

The vast majority of California market squid are frozen for human consumption and exported to China, Japan, and Europe. Other uses include fresh and canned squid for human consumption, and fresh or frozen squid for use as bait in other fisheries. The role of international buyers in the temporal success of the California market squid fishery is substantial. After decades of generally low catches, volume increased during the 1990's because of new (primarily Asian and European) markets and higher prices paid for squid from California waters. Although the volume of squid produced by California markets depends on the international market, the price paid to fishermen can influence both effort exerted toward fishing operations and the overall volume of catch. Additionally, the price paid to fishermen for their catch depends not only on market demand but availability of the resource.

California's market squid fishery is separated at Point Conception, California, into northern and southern fisheries. Historically, the northern fishery accounted for the majority of the catch; however, the southern fishery has dominated landings since the mid 1980's. Although market squid are caught year-round in some years, the northern fishery typically occurs during the summer–fall months, and the southern fishery occurs in the winter–spring

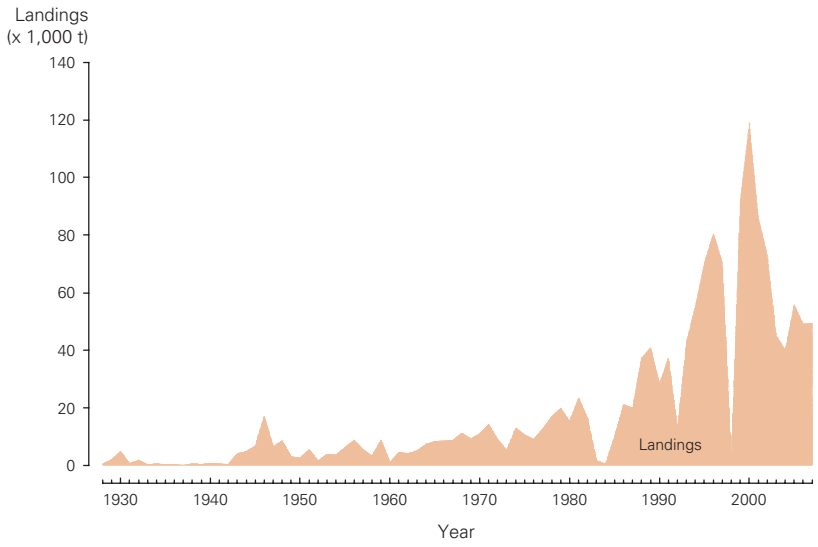

Figure 14-5
Landings in metric tons (t) of market squid in California, 1928–2007.

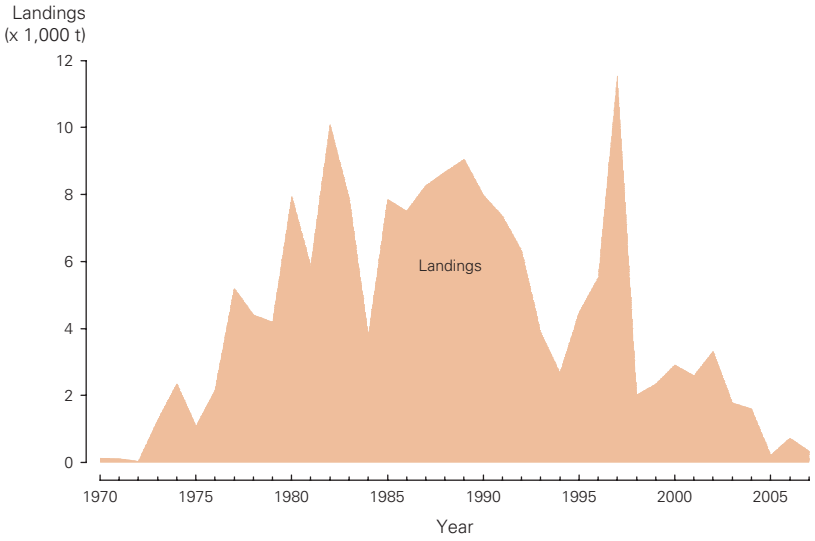

Figure 14-6
Commercial landings in metric tons (t) of Pacific herring off the Pacific Coast, 1970–2007.

months. California landings plummet during the cyclical El Niño oceanographic regimes, but increase considerably when these relatively warm-water oceanic events are displaced by cool-water processes (i.e. La Niña regimes). For example, during the 1997–98 El Niño, landings declined to an estimated 2,900 t, but they rebounded during the 1999 La Niña to nearly 92,000 t and hit a record high in 2000 with approximately 119,000 t landed statewide (Figure 14-5). A moderate El Niño event in 2002–03 likely contributed, to some degree, to an overall decrease in landings coastwide (estimated 73,000 t). Although the southern fishery for market squid was hampered during this oceanographic phenomenon, the northern fishery experienced record landings. The U.S. recent average yield for California market squid is nearly 52,000 t (Table 14-1).

Currently, California market squid are monitored and managed based on a catch limit of 118,000 t and a 2-day weekend closure. The stock is also monitored using biological proxies developed from the interactions between this species' reproductive output (egg escapement) and fishing pressure (fishing mortality, F). Egg escapement is defined here as the number (or proportion) of a female squid's potential lifetime fecundity that she is able to spawn, on average, before being harvested in the fishery. The egg escapement model is based on conventional yield and spawning biomass-per-recruit theory and application. Ultimately, the population assessment method can be used to assess whether the fleet is fishing above or below a predetermined sustainable level of exploitation, and in this context can be used as an effective management tool.

Pacific Herring

In the contiguous United States, Pacific herring are fished primarily off California. The fishery in Puget Sound, Washington, is small by comparison. The fishery off California has peaked three times in recent decades: in 1982 at over 10,000 t, in 1989 at about 9,000 t, and in 1997 around 11,500 t (Figure 14-6). Landings have since decreased to a recent average of 85 t. In the earlier years, Pacific herring were harvested for reduction into fishmeal and for pet food or bait. Some were canned to supplement the declining supply of sardines. Canned herring proved to be a poor substitute for sardines, and the fishery for human consumption ended in 1954.

Since 1973, Pacific herring in California have been harvested primarily for their roe to export to the Japanese market. Landings declined in 1984 when an El Niño episode caused a corresponding

decline in the herring population. However, most stocks have recovered somewhat and so have catches. The herring roe fishery is limited to California's four largest herring spawning areas: San Francisco Bay, the Tomales–Bodega Bay area, Humboldt Bay, and the Crescent City harbor. San Francisco Bay has the largest spawning population of herring and supplies more than 90% of the state's herring catch. The four spawning areas are managed separately by CDFG, with catch quotas based on population estimates.

Another lucrative segment of the Pacific herring industry is the roe-on-kelp fishery (Figure 14-7). Beginning in 1965, scuba divers harvested species of marine vegetation with herring eggs attached in Tomales and San Francisco Bays. This product is exported to Japan as a holiday delicacy. The fishery has evolved into the present roe-on-kelp fishery. Giant kelp is harvested from the Channel Islands off Southern California, brought to San Francisco Bay, and suspended from 60- by 40-ft floating rafts. The rafts are towed to areas where herring spawning is expected to occur and are anchored. After spawning has ended, the kelp with herring eggs attached is removed from the rafts and packed in salt. Catches have been generally low (Figure 14-7) but valuable.

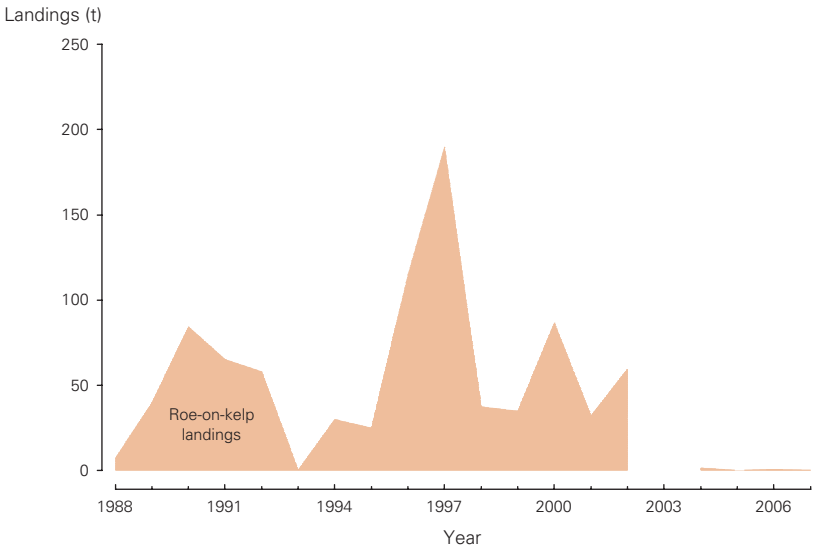

Figure 14-7
Landings in metric tons (t) of herring roe and kelp from the roe-on-kelp fishery in California, 1988–2007. Data unavailable for 2003.

ALASKA PELAGIC FISHERIES

Pacific Herring

Pacific herring is the major pelagic species harvested in Alaska. The fisheries occur in specific inshore spawning areas of the Gulf of Alaska and the Bering Sea. In the Gulf of Alaska, spawning fish concentrate mainly in Southeast Alaska, in Prince William Sound, and around the Kodiak Island–Cook Inlet area. In the Bering Sea, the centers of spawning abundance are in northern Bristol Bay and the eastern shore of Norton Sound. This fishery occurs within state waters (0–3 n.mi. offshore), and is therefore monitored and managed by the Alaska Department of Fish and Game (ADFG). ADFG manages the fisheries by 20 separate fishery statistical areas.

Herring spawn every year after reaching sexual maturity at 3 or 4 years of age. The number of eggs varies with the age of the fish and averages 20,000. The average life span for these fish is about 8 years in Southeast Alaska and up to 16 years in the Bering Sea.

Alaska's herring industry began as early as 1878 when about 14 t were marketed for human consumption. The fishery expanded rapidly in the late 1800's and early 1900's, with markets shifting from salt-cured herring to reduction products for fishmeal and oil. By 1934 the catch from the Gulf of Alaska alone had reached a record 140,000 t. The Bering Sea fishery began in the late 1920's, initially with a small salt-cure plant in Dutch Harbor. A large foreign offshore fishery developed in the 1950's and peaked dramatically in 1970 at more than 145,000 t. It then fell off sharply to 16,000 t in 1975 (Figure 14-8). Since 1977, Bering Sea herring have been harvested primarily in inshore sac roe fisheries, and catches have since risen slowly but steadily. A portion of the Bering Sea harvest is taken as bycatch in the offshore Federally managed groundfish fishery. Retention of herring in these fisheries is prohibited, with regulations limiting herring bycatch to no more than about 1,000 t annually. From 2003 to 2007 the actual herring bycatch averaged 763 t.

From catch records, it is evident that herring biomass fluctuates widely due to influences of strong and weak year-classes. Herring abundance levels typically increase abruptly following major recruitment events, then decline over a number of years because of natural and fishing mortality. Prince William Sound herring continue to be de-

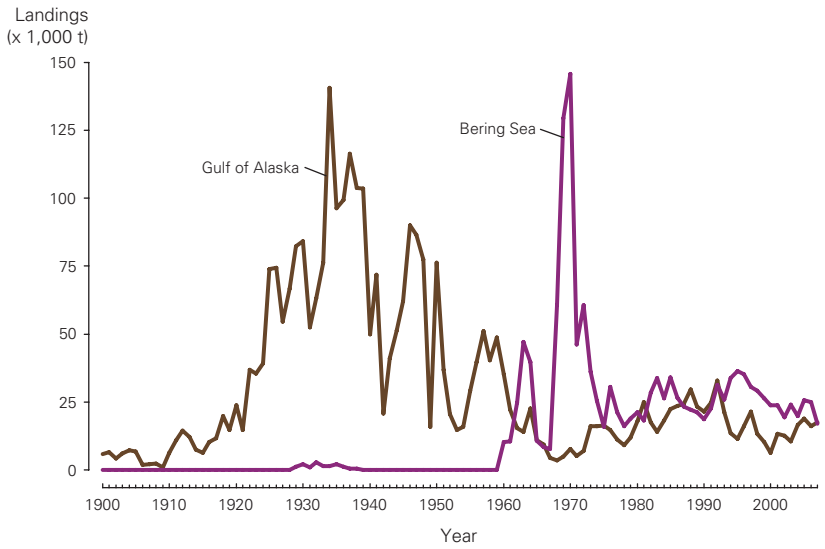

Figure 14-8
Landings in metric tons (t) of Pacific herring off Alaska, 1900–2007.

pressed from a disease outbreak in 1993. In the past 5 years, statewide herring harvests have averaged about 38,000 t, with a value averaging around $12,000,000. About 5% of the commercial harvest is taken for food and bait, and the rest is taken in the sac roe fisheries. In addition, there is a roe-on-kelp fishery that harvests about 300 t of product annually, with a value of around $2,900,000. Currently, the herring populations in Alaska remain at moderate levels and are in relatively stable condition, with the exception of Prince William Sound and Cook Inlet.

ISSUES

Transboundary Stocks and Jurisdiction


Anne Allen, SWFSC

Pacific sardine.

Sardine, anchovy, and mackerels are transboundary stocks exploited by both U.S. and Mexican fleets, but no bilateral management agreement has yet been reached for coordinated management of the stocks. Harvest policies in the CPS FMP take into account approximate stock portions residing in U.S. waters and prorate allowable harvest accordingly. Aside from minimum size requirements, CPS harvest levels are unregulated in Mexican waters, and the absence of a governing bilateral agreement is compromising management of the stocks that are fished by both countries. This problem is confounded by ongoing uncertainty regarding stock structure, distribution, and environmental influences on these highly dynamic populations.

Underutilized Species

Jack mackerel and northern anchovy are underutilized species and may support increased harvest by U.S. fishermen in the near future.

PROGRESS

Scientists from the National Marine Fisheries Service continue to work closely with state biologists and the Pacific Fishery Management Council in assessing and managing the stocks. Stock assessment models have been developed for northern anchovy, Pacific sardine, and Pacific mackerel. The models now use more data, including fish-spotter data from pilots employed by commercial fishermen, and the California Cooperative Oceanic Fisheries Investigations' (CalCOFI) long-term ichthyoplankton data base. Recent progress has been made toward improving collaborative research and data sharing between U.S. and Mexican scientists.

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