Pacific Coast Salmon

David Csepp

Unit
12

ROBERT G. KOPE

NMFS Northwest Fisheries
Science Center

Seattle
Washington

Photo above:
Male coho salmon showing spawning coloration and physical condition.

INTRODUCTION

Pacific salmon support important commercial and recreational fisheries in Washington, Oregon, and California. Salmon are a vital part of the culture and heritage of the Pacific Northwest, having been harvested by Native Americans for millennia and by European settlers since their arrival on the Pacific Coast of North America.

Pacific salmon include five species: Chinook, coho, sockeye, pink, and chum salmon. All are anadromous: they spawn in fresh water and migrate to the ocean where they may undergo extensive migrations. At maturity, they return to their home stream to spawn and complete their life cycle. Coho salmon and most southern U.S. runs of Chinook salmon tend to stay over the Continental Shelf during their ocean residency, where they are vulnerable to fisheries as immature fish. Sockeye, pink, and chum salmon migrate farther offshore and rear in the Gulf of Alaska and central North Pacific Ocean. These species are only vulnerable to shore-based fisheries as mature fish on their spawning migrations.

Chinook and coho salmon are harvested recreationally and commercially in the Pacific Ocean, Puget Sound, and in freshwater rivers on their spawning migrations. All recreational fisheries use hook-and-line gear, whereas commercial fisheries use a variety of gear depending on location. In the Pacific Ocean all harvest is by trolling; in Puget Sound, gillnets and purse seines are used in addition to trolling; in fresh water and estuaries, gillnets are the primary gear used. Pink, chum, and sockeye salmon are not as important to recreational fisheries as Chinook and coho salmon, and are uncommon in recreational catches outside of Puget Sound. While there are intense recreational fisheries directed at these species in a few locations, the majority of harvest is by commercial gillnet and purse seine fisheries in Puget Sound and gillnet fisheries in estuaries. All species are also harvested for subsistence and ceremonial purposes by Native American tribes.

Table 12-1
Productivity in metric tons (t) and status of Pacific Coast salmon fisheries resources. Harvest rate and stock status information for Pacific Coast salmon are available for individual runs, but cannot be calculated for coastwide stocks. For more information on the status of individual salmon runs, see the *Status of U.S. Fisheries Reports* available online at http://www.nmfs.noaa.gov/sfa/statusoffisheries/SOSmain.htm.

Species/stock	Recent average yield (RAY)[1]	Current yield (CY)[2]	Sustainable yield (MSY)[2]	Stock level relative to B_{MSY}[3]
Chinook salmon	8,919	11,460	11,460	Near
Chum salmon	6,170	4,636	4,636	Near
Coho salmon	3,127	5,300	5,300	Near
Pink salmon	1,846	7,270	7,270	Near
Sockeye salmon	1,048	4,646	4,646	Near
Total	21,110	33,312	33,312	

[1]2004–06 average, except for pink salmon which is for the years 2001, 2003, and 2005. Recreational harvests were converted from numbers of fish to approximate weights using average weights of salmon caught in commercial fisheries from 1999–2006: Chinook = 6.00 kg; chum = 3.79 kg; coho = 3.04 kg; pink = 1.75 kg; sockeye = 2.32 kg.

[2]Potential yields include doubling of production for some stocks.

[3]*B* is biomass. B_{MSY} represents the stock size that can withstand maximum sustainable yield without collapsing.

During 2004–06, the annual commercial salmon catch averaged 16,300 metric tons (t) and provided revenues averaging approximately $40 million at dockside. Recreational catches are more difficult to value since the recreational experience associated with the catch cannot be easily measured. If recreationally caught fish are valued at a conservative $20 per fish, the 2004–06 average catch of 800,000 fish would have been worth about $16 million annually. Total recent average annual landings (2004–06) were more than 21,000 t (Table 12-1).

The abundance of individual stocks of Pacific salmon and the mixture of stocks contributing to fisheries fluctuate considerably. Consequently, annual landings fluctuate as well. For all species, there is excess fishing capacity and overcapitalization of the fishing fleets. Although harvest rates in recent years have been held near or below levels that would produce the maximum sustainable yield, recent environmental conditions have resulted in poor ocean survival of Chinook and coho salmon stocks in general and some individual stocks of the other species. This has led to sharp declines in abundance of most southern stocks over the past 5 years and has led to the closure of all 2008 ocean salmon fisheries off the coasts of Oregon and California, except for a small recreational coho fishery off the coast of Oregon which only allows retention of marked hatchery fish.

Management Situation

The management of this resource is complex, involving many stocks originating from various rivers and jurisdictions. The Pacific Fishery Management Council (PFMC), in cooperation with the states and tribal fishery agencies, manages ocean fisheries for Chinook and coho salmon under a framework fishery management plan (FMP). Within Puget Sound and the Columbia River, the states and tribes manage fisheries for these two species. The Pacific Salmon Commission (PSC), the State of Washington, and tribal fishery agencies primarily manage fisheries for pink, chum, and sockeye salmon.

Fisheries are managed using a variety of regulations. Ocean fisheries are managed mainly through

William Heard, AFSC

Photo to right:
School of juvenile pink salmon in a healthy river.

gear restrictions, minimum size limits, and time and area closures, although harvest quotas have been in place for individual fisheries in recent years. The PSC uses harvest quotas (updated on the basis of in-season abundance forecasts) and cumulative impact quotas for weak stocks to regulate some commercial fisheries in the Strait of Juan de Fuca and north Puget Sound.

Pacific salmon depend on freshwater habitat for spawning and rearing of juveniles. Because the quality of freshwater habitat is largely a function of land management practices, salmon production is heavily influenced by entities not directly involved in the management of fisheries. Salmon management involves the cooperation of the U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Bureau of Reclamation, Army Corps of Engineers, Environmental Protection Agency, Bonneville Power Administration, state resource agencies, Indian tribes, municipal utility districts, agricultural water districts, private timber companies, and landowners.

Following coast-wide status reviews for all species of salmon and anadromous trout, numerous evolutionarily significant units (ESU's) of all species except pink salmon have been listed as threatened or endangered under the U.S. Endangered Species Act (ESA). As a result, most freshwater habitat supporting anadromous salmonids now includes listed species. The need to reduce impacts on listed stocks has constrained allowable harvest rates on healthy stocks in recent years. In order to access hatchery-produced salmon, most hatchery-produced coho salmon are currently being marked by removal of the adipose fin to distinguish them from wild salmon. In most hook-and-line fisheries allowing retention of coho salmon, all unmarked fish must be released. Similar mass marking of hatchery-produced Chinook salmon has begun in many hatcheries, and limited mark-selective fisheries have been implemented for this species as well.

SPECIES STATUS

Chinook Salmon

The main production areas for Chinook salmon are rivers and hatcheries in Puget Sound in Washington, the Umpqua and Rogue Rivers in Oregon, the Klamath and Sacramento Rivers in California, and the Columbia River. Stocks are named for the season in which they migrate from the ocean to freshwater to spawn, and include spring, summer, fall, and winter runs. Chinook salmon production tends to fluctuate considerably (Figure 12-1) depending on hatchery production, freshwater habitat conditions, and ocean productivity. The proportion of Chinook salmon production originating from hatcheries has been increasing. In recent years, freshwater habitat loss and degradation have been exacerbated by drought in many areas in the west, in addition to generally unfavorable ocean conditions for Chinook salmon from the late 1970's through the late 1990's. This resulted in historically low abundance for a number of stocks and reduced commercial and recreational catches in many areas.

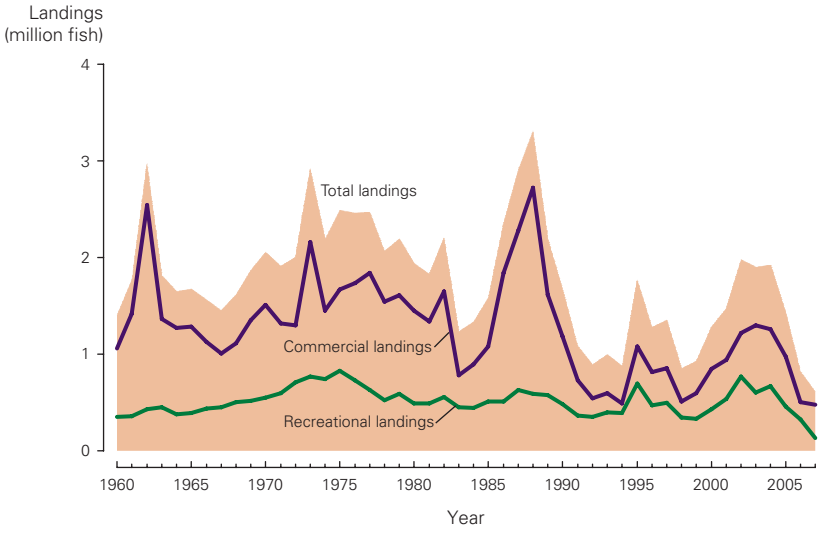

Figure 12-1
Chinook salmon landings in individual fish, 1960–2007.

Currently, the upper Columbia River spring-run and the Sacramento River winter-run ESU's are listed as endangered under the ESA and seven additional ESU's are listed as threatened. Concern over the depressed status of stocks and biological opinions requiring reduced impacts on listed ESU's led to increasingly restrictive ocean fishing seasons through most of the 1990's. Improvements in marine survival beginning around 1999 allowed for brief modest increases in harvests and improvements in spawner abundance for most Chinook salmon stocks. However, since 2004 most populations originating south of the Columbia River have declined sharply.

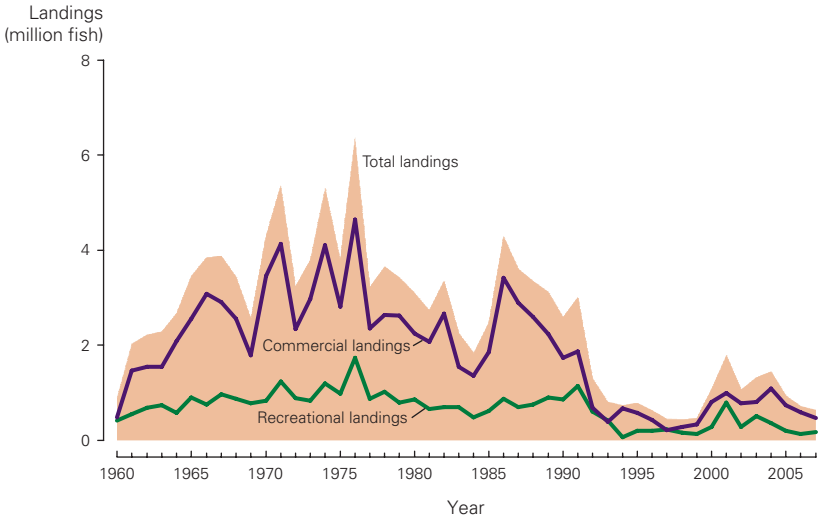

Figure 12-2
Coho salmon landings in individual fish, 1960–2007.

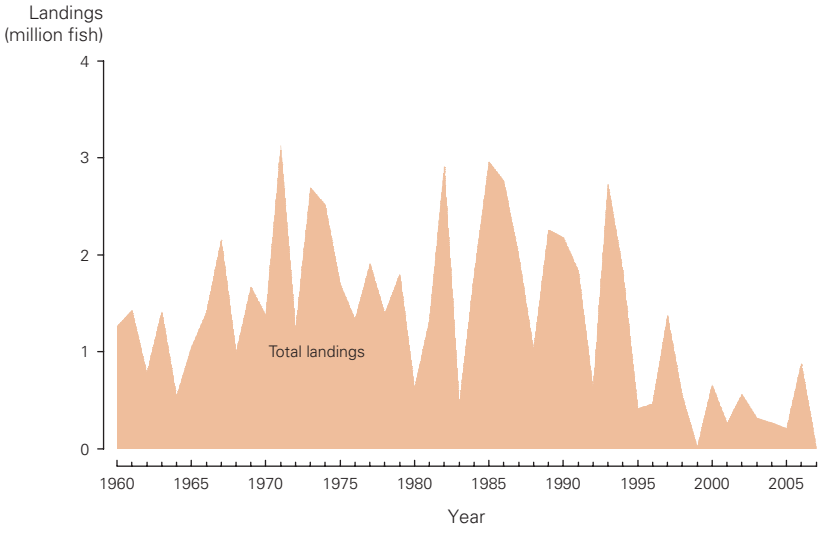

Figure 12-3
Sockeye salmon landings in individual fish, 1960–2007.

Coho Salmon

Coho salmon are produced primarily in rivers and hatcheries in the Puget Sound area in Washington, hatcheries on the Columbia River, and coastal rivers and hatcheries in Oregon and California. Hatcheries play a larger role in the production of coho salmon than they do for Chinook salmon; in some areas, hatcheries account for more than 80% of the abundance available to fisheries. Landings reductions during the 1990's resulted from record low abundances of several stocks of coho salmon, including Oregon coast natural and Columbia River hatchery stocks (Figure 12-2). To protect the spawning escapement of these stocks and to provide fish for the legally mandated tribal allocation, severe restrictions have been placed on ocean fisheries since 1993. Since then, natural populations of coho salmon in the United States have also benefited from reductions in Canadian coho-directed fisheries to protect depressed Canadian stocks and the implementation of mark-selective regulations in most U.S. ocean fisheries, under which only hatchery-marked coho may be retained and unmarked natural coho must be released.

Currently, three coho salmon ESU's are Federally listed as threatened: northern California-southern Oregon in 1997; Lower Columbia River in 2005; and Oregon Coast ESU, which was originally listed in 1998 but had the listing overturned by a Federal district court in 2001 and was re-listed in 2008. Additionally, the central California ESU, formerly listed as threatened, was upgraded to endangered in 2005.

Sockeye, Pink, and Chum Salmon

Pink and chum salmon originate primarily from the tributaries of Puget Sound, Washington. Chum salmon are also produced, in limited numbers, in the Columbia River and coastal streams as far south as the central Oregon coast. Sockeye salmon originate primarily from river systems connected to lakes. They are produced in a few rivers in the Puget Sound area, in limited numbers in a few coastal rivers on the Olympic Peninsula, and in the upper Columbia and Snake River basins. The majority of these species are caught commercially in the Puget Sound region of Washington. Much of the sockeye and pink salmon harvested in Puget Sound originates from the Fraser River in Canada. Chum salmon in Puget Sound have been doing very well, and recent abundance has been near record levels. Sockeye runs in the Fraser River have been erratic in the past decade. There have been large changes in survival and run timing for several runs, and some run components are under consideration for listing under Canada's Species at Risk Act. Pink salmon in Puget Sound rebounded from a record

low return in 1999 to near record high abundance in recent years. However, commercial fisheries have been constrained by a combination of low price and incidental impacts on sockeye and listed Chinook populations. Historical landings of the species are shown in Figures 12-3, 12-4, and 12-5 for sockeye, chum, and pink salmon, respectively.

Recreational Fisheries

Pacific salmon support valuable recreational fisheries in salt water, fresh water, and estuaries. Recreational landings of Chinook salmon have averaged about 480,000 fish annually for the period 2004–06. During the same period, recreational landings of coho salmon have averaged about 230,000 salmon from hatchery and natural production combined. These landings reflect a substantial decline in abundance since 2004.

Recreational landings for sockeye and chum salmon have averaged 25,000 and 10,000 fish annually over the 2004–06 period. In years when pink salmon are available, they normally account for the bulk of recreational landings for these species, but there are only significant runs in odd-numbered years. Recreational landings of pink salmon from the 2001, 2003, and 2005 runs averaged nearly 214,000 fish. While recreational landings of Chinook and coho are comparable to commercial landings, recreational landings of pink, chum, and sockeye account for a much lower proportion of the total catch. The reason for this lies partly in the life histories and migration patterns of the individual species. Sockeye, pink, and chum salmon migrate far offshore into the central North Pacific Ocean and the Gulf of Alaska. Thus they are only available to recreational fisheries briefly during their spawning migration. In addition, pink and chum salmon spawn and die shortly after entering fresh water as adults. By the time they reach terminal areas where recreational fisheries are located, they have undergone physiological changes in preparation for spawning, reducing the quality of their flesh and making them less highly prized relative to Chinook, coho, and sockeye salmon. While the recreational fisheries for sockeye, pink, and chum salmon are substantially smaller than recreational fisheries for Chinook and coho salmon, they are still important.

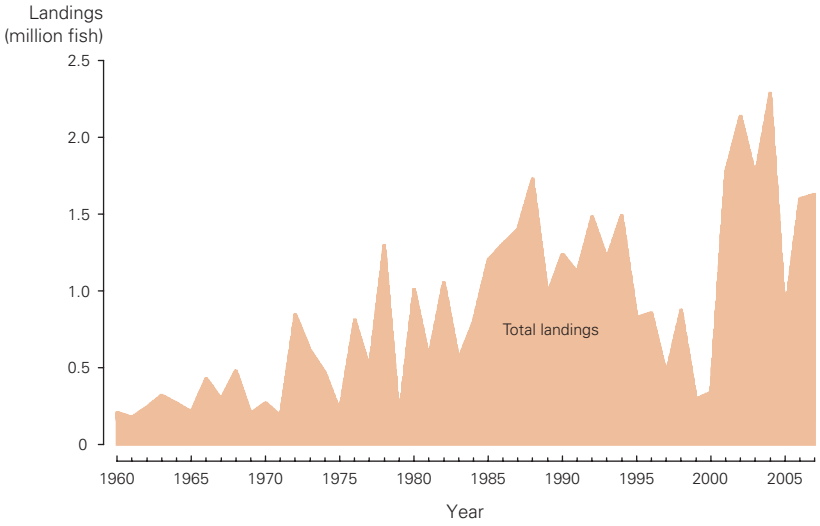

Figure 12-4
Chum salmon landings in individual fish, 1960–2007.

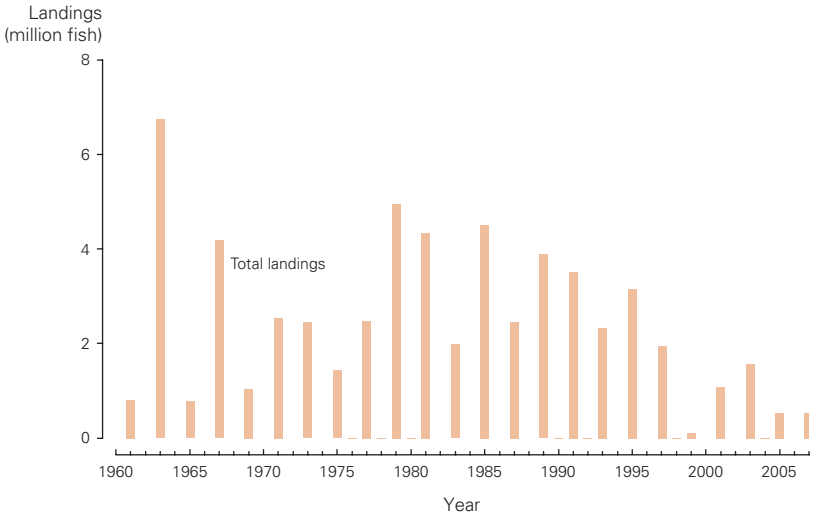

Figure 12-5
Pink salmon landings in individual fish, 1960–2007.

Commercial Fisheries

For 2004–06, the combined Chinook salmon harvest from natural and hatchery production averaged about 910,000 fish. In the same period, the commercial catch of coho salmon averaged about 799,000 salmon. Both species experienced brief rebounds from very low abundance levels in the 1990's. However, since 2003, stocks originating south of the Columbia River have declined sharply,

OAR/National Undersea Research Program

Spawning salmon in a Washington State fish hatchery.

culminating in the 2008 closure of all commercial salmon fisheries in California and most of the Oregon coast.

Landings of sockeye, pink, and chum salmon demonstrate a very different pattern from those of Chinook and coho salmon. Recent average annual catches of these species were roughly 427,000 sockeye salmon (2004–06), 1.57 million chum salmon (2004–06), and 843,000 pink salmon (2001, 2003, and 2005). Recent trends in landings have generally been stable or increasing, but marked downturns in landings were seen in the late 1990's. Landings of chum salmon have rebounded since then, while landings of pink salmon and sockeye salmon have not. The reasons for these differences are unique for each species.

While landings of chum salmon are mainly made up of stocks from the Puget Sound region, a large proportion of the pink salmon and nearly all of the sockeye salmon landed in Washington State are from stocks originating in the Fraser River system in British Columbia. Pink and chum salmon stocks both increased in abundance around 2000, and while chum landings reflect this rebound, pink salmon landings do not. After rebounding from a record low return in 1999, near record runs of pink salmon in 2001 and 2003 were only lightly harvested because of depressed prices, and incidental impacts on depressed sockeye runs and ESA-listed Chinook runs in Puget Sound. In the case of sockeye salmon, Fraser River runs were strong through the mid 1990's, but ocean conditions have caused a large proportion of the fish to migrate north of Vancouver Island where they were unavailable to U.S. fisheries. Renegotiation of the Pacific Salmon Treaty with Canada also sharply reduced the U.S. share of the catch. In addition, since 1996 the late-run of sockeye salmon has been entering the river earlier than it did historically. The timing of the late-run has advanced as much as 6 weeks, and this early river entry has been associated with high pre-spawning mortality. This unexplained behavior, as well as declines in abundance and shifts in the timing of other run components, has alarmed fishery managers and prompted severe restrictions on harvest in sockeye fisheries.

ISSUES AND PROGRESS

Balancing Competing Uses

The decline in Chinook and coho salmon abundance has forced severe reductions and closures of ocean fisheries in recent years. These reductions, in some cases, follow earlier legally mandated reductions to allocate salmon to interior-water fisheries for harvest by Native American tribes. Ocean salmon fisheries cannot redirect their effort to take advantage of abundant sockeye, pink, and chum salmon stocks because the ocean distribution of these species keeps them outside the range of coastal fisheries. With the prospect of continued restrictions to protect threatened and endangered species and depressed prices, the future viability of these commercial fisheries is uncertain.

Hatchery Versus Wild Salmon

The use of hatcheries to mitigate habitat loss and enhance fisheries, especially for Chinook and coho salmon, has raised concerns about the interactions of hatchery and natural fish. While hatchery fish can supplement natural production, they can also compete with naturally produced fish. In areas where fisheries are managed on the basis of hatchery production, harvest rates may be higher than the natural stocks can sustain. In addition, some hatchery fish fail to return to the hatchery, spawning in natural areas with wild fish. Some hatchery brood stocks are of non-local origin, and the insertion of non-local genes into natural populations can compromise the genetic integrity of the native stocks and decrease their productivity. Even when hatchery stocks are of local origin, multiple generations of hatchery rearing appear to

reduce the fitness of fish to compete and survive in the wild.

Market Competition

One problem faced by commercial salmon fisheries in the Pacific Northwest has been declining prices driven by market competition from record landings of Alaskan salmon and steadily increasing aquaculture production. For example, in 2002 the average ex-vessel price paid for dressed Chinook salmon in California was $1.55/lb, while the 1979 price was $2.53/lb. Prices for other species have declined even more, with pink salmon selling for as little as $0.05/lb in Puget Sound in 2003. Since then, prices have rebounded somewhat, as niche markets for local ocean-caught fish have developed, and catches have declined.

Marine Mammal Interactions

Since the passage of the Marine Mammal Protection Act in 1972, populations of pinnipeds (seals and sea lions) have increased to historic levels. As pinniped populations have increased, so have their interactions with salmon populations and with fisheries. Aggregations of seals and sea lions have appeared at river mouths and dams where migrating salmon are concentrated and more vulnerable to predation. In addition to preying on migrating salmon, some pinnipeds have also specialized in removing salmon from recreational and commercial fishing gear. This has resulted in damage to fishing gear, injuries to pinnipeds, and an increase in the incidental mortality associated with recreational and commercial salmon fishing, but the magnitude of the increase is unknown.

In 2005, Southern Resident killer whales were listed under the Federal ESA as an endangered species. While transient killer whales feed on other marine mammals, the resident killer whales feed primarily on fish. Genetic analysis of observed feeding events and stool samples indicate that Chinook salmon are their preferred prey. The listing of these killer whales and recent declines in Chinook abundance have focused further scrutiny on the ecological impacts of salmon fisheries.

Transboundary Stocks and Jurisdiction

Because salmon migrate long distances, they are subject to interception by fisheries far from their region of origin. Issues of allocation have never been easy to resolve and have been addressed in a variety of forums. Much of the annual process of managing ocean salmon fisheries by the PFMC is concerned with the allocation of fish between different user groups: ocean and interior-water fisheries, commercial and recreational fisheries, and tribal and non-tribal fisheries. The PSC oversees the allocation of salmon between the United States and Canada. In 1994, a breakdown of the United States–Canada negotiations led to aggressive harvesting that compounded forecasting errors and nearly destroyed one of the most productive runs of sockeye salmon from the Fraser River in British Columbia. In 1999 the PSC reached an agreement that established an abundance-based management regime for Chinook salmon, replacing the fixed quotas in major southeast Alaska and British Columbia fisheries with a quota system that changes in response to the aggregate abundance of Chinook salmon available to each fishery. A similar abundance-based management regime for coho salmon was agreed upon in 2002.

David Csepp

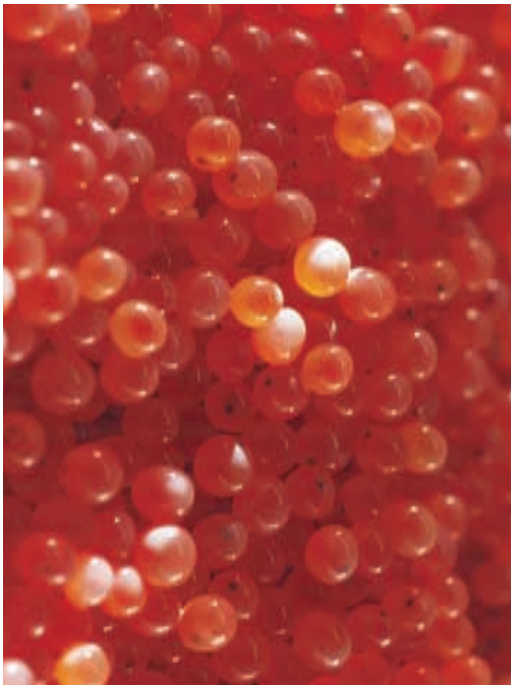

Photo to left:
Fertilized salmon eggs.

Ecosystem Considerations

Coho salmon abundance reached a peak in 1976, and suffered a dramatic decline through the late 1990's. Chinook salmon abundance has also generally declined since the mid 1970's, although there was a brief increase in the late 1980's. These declines affected both hatchery and natural stocks, and appeared to indicate a period of declining ocean survival. These declines were also coincident with a change in the oceanographic regime off the West Coast that occurred around 1978. Since then, the coastal waters off California, Oregon, and Washington, where many Chinook and coho salmon stocks mature, have been warmer and less productive than they were in the period from roughly 1950 to 1978. The decline in ocean productivity off the Pacific Coast appears to be linked to increased productivity in the Gulf of Alaska. Sockeye, pink, and chum salmon, which migrate farther offshore than Chinook and coho salmon, were relatively stable or increasing during the same period that Chinook and coho salmon declined.

More recently, conditions for Chinook and coho salmon briefly improved. In 1999, water temperatures were lower than normal off the coasts of California, Oregon, and Washington. In 2000, the marine plankton assemblages in the Pacific Northwest shifted from species characteristic of temperate regions to species more characteristic of subarctic regions, and bait fish became abundant. However, by 2005 most indicators of ocean productivity in within the California Current system pointed toward poor conditions for survival of Chinook and coho salmon. Indicators have remained unfavorable since then, and Chinook and coho populations south of the Columbia River have continued to decline.

Because Pacific salmon depend on freshwater habitat for spawning and juvenile rearing, they are particularly vulnerable to habitat degradation. Dam construction, logging, agriculture, grazing, urbanization, and pollution have degraded freshwater habitat throughout their range. Water extraction and flow manipulation for hydropower, irrigation, flood control, and municipal needs directly compete with salmon for the fresh water on which they depend. As the human population in the western United States continues to increase, so will the pressures on salmon habitat. The fact that we still have salmon in harvestable quantities is a tribute to the resilience of these fish.

FOR FURTHER READING

Groot, C., and L. Margolis (Editors). 1991. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, BC, Canada, 546 p.

Hare, S. R., N. J. Mantua, and R. C. Francis. 1999. Inverse production regimes: Alaska and West Coast Pacific salmon. Fisheries 24(1):6–14.

ODFW and WDFW. 2002. Status report. Columbia River fish runs and fisheries 1938–2000. Oregon Department of Fish and Wildlife, Portland, OR, and Washington Department of Fish and Wildlife, Olympia, WA, 324 p.

PFMC. 2008. Review of 2007 ocean salmon fisheries. Pacific Fishery Management Council, Portland, OR, 326 p.