North American Wild Salmon Resources

Key Points

✔ North America may be divided into four distinct salmon producing regions: Alaska, British Columbia, the U.S. Pacific Northwest, and the Northeast:

- Alaska has healthy wild salmon stocks, large-scale salmon ranching (hatchery production), high wild catches and no salmon farming.
- British Columbia has much lower and declining wild salmon catches, some hatchery production, and large and growing farmed salmon production.
- U.S. Pacific Northwest salmon stocks are greatly reduced from historic levels. Wild salmon catches are very small relative to Alaska and British Columbia; farmed salmon production is also small. Hatchery production is significant.

✔ The Northeast has very low wild Atlantic salmon populations and no commercial wild salmon fisheries; there is a significant salmon farming industry.

✔ Seven species of salmon return to spawn in North America: Atlantic salmon and five species of Pacific salmon (chinook, sockeye, coho, pink, chum) and steelhead trout (also known as salmon trout or sea-run rainbow trout). Only Pacific salmon, exclusive of salmon trout, are caught commercially.

✔ Wild salmon returns and catches vary widely from year to year and over longer periods of time due to natural factors such as ocean conditions.

✔ Catches of North American salmon are regulated by managers to achieve “escapement” goals for the number of fish reaching the spawning grounds. Catch is determined primarily by the number of fish returning, rather than by economic conditions.

Introduction

In this chapter we provide a brief overview of North American wild salmon resources. We begin by describing and contrasting four salmon producing regions of North America: Alaska, British Columbia, the U.S. Pacific Northwest and the Northeast. Next we briefly review the biology of wild salmon and differences between species of wild Pacific salmon. We then discuss challenges in assessing the health of salmon stocks, including short-run and long-run variation in natural conditions. Finally, we review the status of salmon resources in different salmon producing regions.

North American Salmon Producing Regions

In thinking about North American wild salmon it is useful to divide North America into four salmon producing regions: Alaska, British Columbia, the U.S. Pacific Northwest (Washington, Oregon and California), and the Northeast (Maine, the Maritime Provinces, Quebec and Newfoundland) as in Figure II-1. There are very significant differences between these regions in:

- status of their wild salmon stocks,
- management of salmon fisheries,
- scale of commercial fishing for wild salmon,
- scale of sport and subsistence fishing for wild salmon,
- scale of hatchery production,
- scale of salmon farming,
- issues that they face related to wild and farmed salmon,
- type of data that are available about the salmon fisheries.

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1In this report, we use the terms “hatchery salmon” to refer to salmon released by hatcheries, “natural wild salmon” to refer specifically to wild salmon not released from hatcheries, and “wild salmon” to refer to all salmon that are not farmed. Hatchery salmon are sometimes referred to as “ranched” or “ocean-ranched” salmon. Natural wild salmon are sometimes referred to as “wild stocks” or sometimes simply as “wild salmon.”

Traffic North America
Alaska has healthy wild salmon stocks, wild catches that dwarf those of other regions, and no salmon farming. Hatchery production (discussed further in Chapter IV) accounted for 69 percent of Alaska chum salmon caught and 40 percent of Alaska pink salmon caught during 2000-2002, or 38 percent of the total number of salmon caught. Alaska has banned salmon farming.

British Columbia’s wild salmon industry has experienced a dramatic decline in catches. British Columbia’s farmed salmon production is now more than double its wild salmon catches.

U.S. Pacific Northwest wild salmon catches are tiny compared to those of Alaska. As in British Columbia, the wild salmon industry has experienced a decline in catches. The region is struggling to restore salmon stocks greatly reduced from historical levels by dams, pollution and other factors—including changing ocean conditions. There is a small salmon farming industry in Puget Sound.

Northeast wild Atlantic salmon stocks are extinct in southern New England, severely endangered in Maine, and have fallen dramatically in most of eastern Canada. There are no commercial catches of wild Atlantic salmon. While pollution, stream blockage, fishing and other human factors caused much of the historic decline in wild Atlantic salmon catches, unexplained changes in ocean survival have played a role in the more recent decline. There is significant salmon farming in Maine and New Brunswick (further discussed in Chapter V).

### Wild Salmon Biology

Pacific and Atlantic salmon are members of a large family of fish known as *salmonidae*. Besides Pacific and Atlantic salmon, other species of *salmonidae* are found in North America, including Arctic char and all the trout species. Wild commercial catches of char and trout are insignificant.
Salmon are anadromous: they spawn in fresh water and the young migrate to the sea where they mature. Most salmon return to the stream of their birth, although some may stray to other streams.

Seven species of salmon return to spawn in North America. Five species of Pacific salmon (genus *Oncorhynchus*) return to streams from Northern California to Alaska: chinook, sockeye, coho, pink and chum. Steelhead (also known as salmon trout or sea-run rainbow trout) was recently added to the genus *Oncorhynchus* (*Oncorhynchus mykiss*) but is not commercially caught.

Hundreds of millions of Pacific salmon are caught each year in commercial, sport and aboriginal salmon fisheries. Pacific salmon are also known by a variety of other names, of which red salmon (sockeye), king salmon (chinook), dog salmon (chum) and silver salmon (coho) are the most common. Table II-1 provides the scientific names and common names of each species.

Atlantic salmon (genus *Salmo*) return in limited numbers to streams in New England and the Canadian maritime provinces. An extremely large amount of money has gone into trying to re-establish stocks of Atlantic salmon on the Eastern coast of North America, with little success. There are no North American commercial fisheries for Atlantic salmon.

There are significant differences among Pacific salmon species in freshwater habitat, life history, average harvest weight, roe content and other physical characteristics. These differences play an important role in how salmon of each species are harvested, how they can be processed, recovery rates in processing (edible weight as a percentage of unprocessed or “round” weight), the suitability of the fish for different processes such as the taste and appearance of the fish and the prices they command in different markets. As shown in Table II-2, these factors are reflected in significant differences between species in prices paid to fishermen and the mix of products made from the fish.

### Table II-1  North American Wild Salmon Species

<table>
<thead>
<tr>
<th>Species</th>
<th>Other common names</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific Salmon</td>
<td>Chinook salmon</td>
<td><em>Oncorhynchus tshawytscha</em></td>
</tr>
<tr>
<td></td>
<td>Sockeye salmon</td>
<td><em>Oncorhynchus nerka</em></td>
</tr>
<tr>
<td></td>
<td>Coho salmon</td>
<td><em>Oncorhynchus kisutch</em></td>
</tr>
<tr>
<td></td>
<td>Pink salmon</td>
<td><em>Oncorhynchus gorbuscha</em></td>
</tr>
<tr>
<td></td>
<td>Chum salmon</td>
<td><em>Oncorhynchus keta</em></td>
</tr>
<tr>
<td>Atlantic Salmon</td>
<td>Atlantic salmon</td>
<td><em>Salmo salar</em></td>
</tr>
</tbody>
</table>

### Table II-2  Comparison of Alaska Salmon Species in 2002

<table>
<thead>
<tr>
<th></th>
<th>Chinook</th>
<th>Sockeye</th>
<th>Coho</th>
<th>Pink</th>
<th>Chum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average weight (lbs)</td>
<td>16.6</td>
<td>6.1</td>
<td>7.7</td>
<td>3.4</td>
<td>8.6</td>
</tr>
<tr>
<td>Average price paid to fishermen ($/lb)</td>
<td>$1.38</td>
<td>$0.60</td>
<td>$0.36</td>
<td>$0.10</td>
<td>$0.20</td>
</tr>
<tr>
<td>Share of product volume</td>
<td>Canned</td>
<td>1%</td>
<td>34%</td>
<td>9%</td>
<td>73%</td>
</tr>
<tr>
<td></td>
<td>Fresh</td>
<td>27%</td>
<td>7%</td>
<td>12%</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Frozen</td>
<td>71%</td>
<td>59%</td>
<td>79%</td>
<td>25%</td>
</tr>
</tbody>
</table>

Note: Share of product volume is the relative share of each of these in the total processed weight, not the share of the fish used to make a particular product.

Source: CFEC Alaska Salmon Summary Data 1980-2005 for average weight and average price paid to fishermen; ADFG COAR Data for share of product volume.
The timing of spawning and migration varies among the five species of Pacific salmon. Chinook, coho and sockeye will spawn in the headwaters of a river or lake system and so arrive earlier in the summer than do the pink and chum which spawn closer to tidewater. Because returning salmon do not eat after they have entered fresh water, they leave the ocean heavy with the fats and nutrients on which they subsist during their freshwater phase.

The longer and more rigorous the freshwater trip, the more fat a fish will carry as it leaves the ocean. Fat content, which affects taste, varies not only between species but also between different “runs” of the same species returning to different rivers—giving fish of different runs distinctive tastes.\(^2\) Table II-3 shows the differences in fat content among species.

As salmon approach and enter fresh water, they undergo pronounced physical changes, becoming darker and softer. These changes tend to lower the commercial quality of the fish.\(^3\)

When they reach the spawning grounds, the female excavates a nest in the gravel stream bottom, and the male fertilizes her eggs as she deposits them in the gravel. Both then die within a few days, and their decomposing bodies provide an important source of nutrients for the ecosystem.

Five to seven months after spawning, the young salmon fry emerge from the gravel where the spawning pair deposited and fertilized the eggs the fall before. The time spent in fresh water varies widely between species. Pink salmon fry go to sea almost immediately, while sockeye stay in freshwater lakes for a year or more. These differences in the freshwater part of the life cycle mean that different kinds of river systems are relatively more favorable for different species, resulting in different relative mixes of species caught in different river systems.

Similarly, the time spent at sea varies from one year for pink salmon to as long as five years for chinook salmon. In general, the longer the time spent at sea, the larger the fish when they return.

<table>
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<tr>
<th>Table II-3</th>
<th>Comparison of Fat Content of Salmon Species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wild Chinook</td>
</tr>
<tr>
<td>Total fat content</td>
<td>10.4</td>
</tr>
<tr>
<td>Fatty acids</td>
<td>Saturated</td>
</tr>
<tr>
<td></td>
<td>Monounsaturated</td>
</tr>
<tr>
<td></td>
<td>Polyunsaturated</td>
</tr>
</tbody>
</table>

Note: Data are reported in grams per 100 gram edible portion. Data are for raw (uncooked) fish.


\(^2\) Salmon connoisseurs can identify salmon from different rivers, similar to the way wine connoisseurs can identify wines from different vineyards.

\(^3\) Commercially harvested chum salmon are graded as “brite,” “semi-brite,” or “dark,” depending on the extent to which they have changed color prior to harvest.
### Table II-4  
**Notes on the Life Histories of Pacific Salmon**

**Chinook Salmon.** Chinook salmon may become sexually mature from their second through seventh year, and as a result, fish in any spawning run may vary greatly in size. For example, a mature 3-year-old will probably weigh less than four pounds, while a mature seven-year-old may exceed 50 pounds. Females tend to be older than males at maturity. In many spawning runs, males outnumber females in all but the six- and seven-year age groups. Small chinooks that mature after spending only one winter in the ocean are commonly referred to as “jacks” and are usually males. Alaska streams normally receive a single run of chinook salmon in the period from May through July. The natural range of chinook in North America ranges from the Ventura River in California to Kotzebue Sound in Alaska.

**Sockeye Salmon.** Freshwater systems with lakes produce the greatest number of sockeye salmon. In systems with lakes, juveniles usually spend one to three years in fresh water before migrating to the ocean in the spring as smolts. However, in systems without lakes, many juveniles migrate to the ocean soon after emerging from the gravel. Sockeye salmon return to their natal stream to spawn after spending one to four years in the ocean. While returning adults usually weigh between four and eight pounds, weights in excess of 15 pounds have been reported. Most populations show little variation in their arrival time on the spawning grounds from year to year.

**Coho Salmon.** Adults usually weigh eight to 12 pounds and are 24 to 30 inches long, but individuals weighing 31 pounds have been landed. Coho salmon enter spawning streams from July to November, usually during periods of high runoff. They spend one to three winters in streams and may spend up to five winters in lakes before migrating to the sea as smolts. Time at sea varies. Some males (called jacks) mature and return after only six months at sea at a length of about 12 inches, while most fish stay 18 months before returning as full-size adults. The natural range of coho is tributaries from the San Lorenzo River in Monterey, California to Point Hope, Alaska, and throughout the Aleutian Islands. They are most abundant from central Oregon to southeast Alaska.

**Pink Salmon.** The pink salmon is the smallest of the Pacific salmon found in North America with an average weight of about three and a half to four pounds and average length of 20-25 inches. Adult pink salmon enter Alaska spawning streams between late June and mid-October. Different races or runs with differing spawning times frequently occur in adjacent streams or even within the same stream. Most pink salmon spawn within a few miles of the coast, and spawning within the intertidal zone or the mouth of streams is very common. Pink salmon mature in two years which means that odd-year and even-year populations are essentially unrelated. Frequently in a particular stream the other odd-year or even-year cycle will predominate, although in some streams both odd- and even-year pink salmon are about equally abundant. Occasionally cycle dominance will shift, and the previously weak cycle will become most abundant.

**Chum Salmon.** Chum salmon often spawn in small side channels and other areas of large rivers where upwelling springs provide excellent conditions for egg survival. They also spawn in many of the same places as do pink salmon, i.e., small streams and intertidal zones. Some chum in the Yukon River travel over 2,000 miles to spawn in the Yukon Territory. These have the brightest color and possess the highest oil content of any chum salmon when they begin their upstream journey. Chum do not have a period of freshwater residence after emergence of the fry as do chinook, coho, and sockeye salmon. Chums are similar to pink salmon in this respect, except that chum fry do not move out into the ocean in the spring as quickly as pink fry. By fall they move out into the Bering Sea and Gulf of Alaska where they spend one or more of the winters of their three- to six-year lives. In southeastern Alaska most chum salmon mature at four years of age, although there is considerable variation in age at maturity between streams. Chum vary in size from four to over 30 pounds, but usually range from seven to 18 pounds, with females usually smaller than males.

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Source: Adapted from the Alaska Department of Fish and Game Wildlife Notebook Series. Available at [www.cf.adfg.state.ak.us/geninfo/finfish/salmon/salmhome.htm#species](http://www.cf.adfg.state.ak.us/geninfo/finfish/salmon/salmhome.htm#species)
Challenges in Assessing the Status of Wild Salmon Resources

Before reviewing the status of North American wild salmon resources, it is useful to review why it is difficult to generalize about the status of wild salmon.

First, wild salmon return or formerly returned to thousands of streams over very large areas of northeastern and northwestern North America. The status of salmon resources varies widely across this vast area, not only between regions but also between individual watersheds within regions.

Second, only limited and imperfect data are available for assessing the status of salmon resources. What matters for the health of the resource is the number of fish returning and spawning. But most of the available data are for salmon catches, which do not necessarily correspond to the number of fish returning or spawning. Changes in catches may reflect not only changes in the number of fish returning, but also changes in the ocean environmental conditions, technology of fishing, economic profitability of fishing and commercial fishing regulations.

Third, because of the natural short-run and long-run variation in salmon returns to any given river system, it is not easy to define what constitutes a healthy salmon resource. In any given year or decade, higher or lower salmon returns may reflect more or less favorable natural conditions for salmon survival.

As illustrated in Figure II-2, wild salmon catches (including hatchery fish) fluctuate significantly from year to year. This is mainly due to annual variation in the multiple natural environments which wild salmon experience during their complex migratory life-cycle. Variations in stream temperature, current and turbidity affect salmon survival in freshwater environments. Variation in ocean temperature and currents affect the abundance of salmon predator and prey species and salmon survival in marine environments. Variation in the number of salmon which survive to return to spawn—partly reflecting commercial catches—affects the number of eggs which are laid for future generations. A low or high number of salmon returning to spawn in any given year may be echoed in two to five years (depending upon the species) when the next generation hatched from those eggs returns to spawn.

In addition to this annual variation, a growing body of scientific evidence suggests that the oceans are subject to longer-term changes in physical conditions such as temperature and currents, known as “regime shifts,” which affect nutrient upwelling and availability of feed for salmon and their prey and predator species and in turn the ocean survival rates of salmon. The causes of regime shifts are not well understood, nor the mechanisms by which they affect ocean survival of wild salmon. Changes in ocean conditions may be favorable for salmon in some parts of their range and unfavorable in other parts of their range. However, it is increasingly recognized that they may play an important role in long-term increases or decreases in salmon abundance.

As shown in Figure II-3, there were significant fluctuations in average decadal catches of wild Pacific salmon (including hatchery salmon) during the twentieth century. While part of these long-term fluctuations may be attributed to changes in the commercial fishing effort and high-seas interception, they are also correlated with multi-decadal regime shifts in North Pacific Ocean temperatures and currents.

Put generally, a healthy salmon resource—or more broadly, a healthy ecosystem—has high natural variability. It is difficult to determine the extent to which changes in the number of salmon returning or spawning reflect this natural variability or are caused by “un-natural” human-related factors, such as over-fishing, pollution or alteration of stream environments.

As our understanding of salmon biology improves, there is increasing realization that the health of salmon populations depends not only on the number of fish but also on variation within salmon populations. Salmon are uniquely adapted to return to particular river systems at particular times and to survive the particular temperature ranges and water conditions associated with those river systems. For a given species in a given river, there may be several different “runs” which return at different times. What matters is not the total number of salmon returning to any given river, but the returns of each “run.”

Further, there is increasing realization of the importance of genetic diversity within a given salmon run. The long-run survival of the population depends on the presence of some fish able to survive environmental shocks such as particularly cold or hot water temperatures. But it is only very recently that techniques have been devised to measure the extent of genetic diversity within salmon populations, and we have very little information about the extent to which there may have been changes over time in genetic diversity of wild salmon stocks. It is also unclear what the effect of hatchery production has been on the genetic diversity of salmon.

In summary, assessing the environmental status of salmon resources, and the causes of change over time, is difficult. This poses a dilemma for resource managers and for the policy debate over how to rebuild and/or sustain wild salmon resources. Higher catches do not necessarily mean stocks are healthier or that we are doing better in managing salmon resources; lower catches do not necessarily mean stocks are less healthy or that we are doing worse.4,5

4 In an August 2003 speech, President Bush stated “the good news is that salmon runs are up. We can have good, clean hydroelectric power and salmon restoration going on at the same time.” United States Senator and Presidential candidate Joseph Liebermann responded that “George Bush taking credit for increased salmon populations is like a sailor taking credit for the tides” (Geranios 2003).

5 The Atlas of Pacific Salmon (Augerot 2005) provides an excellent and beautifully illustrated overview of factors affecting Pacific salmon resources and their status across their historical range in North America and Asia.

The Great Salmon Run: Competition Between Wild and Farmed Salmon
Figure II-2  Alaska and British Columbia Annual Commercial Catches of Sockeye and Pink Salmon, 1980-2005

Figure II-3  Alaska and British Columbia Average Decadal Commercial Catches of Sockeye and Pink Salmon, 1900-2005


Alaska Wild Salmon Resources

Figure II-4 shows total Alaska commercial salmon catches, including hatchery salmon, since the beginning of commercial salmon fishing during the 1880s, as measured in thousands of fish. Total catches increased rapidly in the four decades after 1880 and remained high during most of the 1920s and 1930s, reflecting increasingly intensive and extensive exploitation of Alaska salmon resources. The primary product produced from salmon in the 1920s and 1930s was canned salmon. Large canneries dotted the coast from California up to Alaska, and the workers along the processing lines in the canneries were often Chinese and Japanese. The amount of canned salmon produced was referred to as the ‘salmon pack.’

Cooley (1963) described this process as follows:

During the early years when the industry was developing at a rapid rate the supply of fish presented no obstacles to expansion. Only the most productive areas and the species of highest quality were being exploited. Lack of markets was the main limiting factor. As depletion occurred in a particular area the industry was able to expand into other regions and to the production of the lower grade species as market conditions warranted. As a result, the total output continued to rise.

From the 1920s onward, the physical limitations of supply became a factor of growing importance. By this time markets were well established. All species were being exploited heavily, but there were fewer and fewer opportunities to offset depletion by expanding operations into new fishing areas. The trend in the total pack continued upward, but the rate of growth was decreasing and there were extreme oscillations in the pattern of output as a result of heavy fishing pressures. After the peak packs in the 1930s, there was a continuous decrease in the supply of fish in every region of Alaska.

This scouring process tended to mask the seriousness of depletion in specific instances, especially during the period when the total pack of canned salmon was increasing. By the time the total pack began to waiver and show definite signs of decline, the resource had already been seriously depleted in many areas and some of the major salmon producing streams had been all but wiped out. (Cooley 1963, p. 41-42)

During the 1940s and 1950s, Alaska experienced a long period of decline in salmon catches. Alaskans bitterly attributed this decline to federal mismanagement and over-fishing by the Seattle-based salmon canning companies which owned most of the fishing boats as well as the salmon traps which caught a large share of the fish. Resentment against the canneries and a desire to gain control of the salmon fisheries played an important role in the drive for Alaska statehood during the 1950s.

After Alaska became a state in 1959, it assumed management responsibility for Alaska salmon, and immediately banned the use of salmon traps. The state adopted a conservative “abundance-based”

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**Figure II-4** Alaska Commercial Salmon Catches, 1880-2005 (all species, thousands of fish)

managersisto assurethatenough salmon reach the
commitment to habitat protection, and how much is
resources compared with other areas. It is a different
important factor in the relative health of Alaska's salmon
disturbance to the freshwater environment has been an
part of the dramatic increase in catches after
was probably due to more favorable ocean
conditions following another regime shift.
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resources. A 2000 review of Alaska salmon fisheries
member to reach escapement goals for a particular time period have been
the amount of time fishermen have to fish thus
varies depending upon the strength of the salmon run. If
the run is weak, fishermen may be allowed to fish
continuously; if the run is strong, fishing may be closed
for many days at a time or even for an entire season.
Because managers' overriding goal is to achieve
escapement targets, and managers can and do completely
close salmon fishing unless and until escapement goals
are met, escapement targets are usually achieved except
in years of very weak salmon runs.
Some observers have commented that Alaska should
not be complacent about the condition of its salmon
resources. A 2000 review of Alaska salmon fisheries
commissioned by Trout Unlimited (Konigsberg 2000) concluded:

"The State of Alaska has demonstrated leadership in
salmon management and conservation. Fortunately,
the freshwater and coastal marine habitats upon
which Alaska salmon production depends have been
relatively unimpaired physiographically, except for
some of those watersheds in Southeast Alaska and
the Gulf of Alaska that have been extensively
logged. Good habitat, in conjunction with what had
apparently been a period of favourable marine
conditions, resulted in exceptionally high salmon
production from the late 1970s through the mid-
1990s. In other words, the apparent success of
Alaska's salmon management has been due, in large
part, to fortuitous circumstances. . .

While total salmon harvests in the 1990s have been
extremely high, it would be a mistake to treat
abundance as a proxy for healthy salmon
populations. High returns can mask diminished and
diminishing genetic diversity among salmon
stocks. . . . Fisheries management that seemed
relatively effective during periods of high
productivity and/or relatively predictable climatic
cycles may not be so effective in the future."

As described in the ADFG "Alaska Salmon
Management" brochure, Alaska utilizes "in-season,
abundance-based management" of commercial salmon
catches. Each year, the overriding goal for salmon fishery
managers is to assure that enough salmon reach the
spawning grounds to ensure healthy future generations of
salmon. Managers have target goals for optimal
"escapements," or numbers of fish that "escape"
commercial, sport and subsistence fisheries to reach the
spawning grounds. Only "surplus" fish in excess of this
escapement goal are available to be caught.

As noted by Scientific Certification Systems (2000), to
reach escapement goals, throughout the fishing season
commercial fishery managers monitor the number of fish
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the run is strong, fishermen may be allowed to fish
continuously; if the run is weak, fishing may be closed
for many days at a time or even for an entire season.
Because managers' overriding goal is to achieve
escapement targets, and managers can and do completely
close salmon fishing unless and until escapement goals
are met, escapement targets are usually achieved except
in years of very weak salmon runs.

Some observers have commented that Alaska should
not be complacent about the condition of its salmon
resources. A 2000 review of Alaska salmon fisheries
commissioned by Trout Unlimited (Konigsberg 2000) concluded:

"The State of Alaska has demonstrated leadership in
salmon management and conservation. Fortunately,
the freshwater and coastal marine habitats upon
which Alaska salmon production depends have been
relatively unimpaired physiographically, except for
some of those watersheds in Southeast Alaska and
the Gulf of Alaska that have been extensively
logged. Good habitat, in conjunction with what had
apparently been a period of favourable marine
conditions, resulted in exceptionally high salmon
production from the late 1970s through the mid-
1990s. In other words, the apparent success of
Alaska's salmon management has been due, in large
part, to fortuitous circumstances. . .

While total salmon harvests in the 1990s have been
extremely high, it would be a mistake to treat
abundance as a proxy for healthy salmon
populations. High returns can mask diminished and
diminishing genetic diversity among salmon
stocks. . . . Fisheries management that seemed
relatively effective during periods of high
productivity and/or relatively predictable climatic
cycles may not be so effective in the future."

As described in the ADFG "Alaska Salmon
Management" brochure, Alaska utilizes "in-season,
abundance-based management" of commercial salmon
catches. Each year, the overriding goal for salmon fishery
managers is to assure that enough salmon reach the
spawning grounds to ensure healthy future generations of
salmon. Managers have target goals for optimal
"escapements," or numbers of fish that "escape"
commercial, sport and subsistence fisheries to reach the
spawning grounds. Only "surplus" fish in excess of this
escapement goal are available to be caught.

As noted by Scientific Certification Systems (2000), to
reach escapement goals, throughout the fishing season
commercial fishery managers monitor the number of fish
entering river systems after passing the commercial
fisheries. They allow fishermen to fish only when
escapement goals for a particular time period have been
met. The amount of time fishermen have to fish thus
varies depending upon the strength of the salmon run. If
the run is strong, fishermen may be allowed to fish
continuously; if the run is weak, fishing may be closed
for many days at a time or even for an entire season.
Because managers' overriding goal is to achieve
escapement targets, and managers can and do completely

This Alaska Department of Fish and Game brochure exemplifies the general perception within Alaska that Alaska’s salmon management is “A Story of Success” attributable to conservative management, sound science and habitat protection.

Alaska’s Salmon Management
Story of Success

Management programs and policies promote the sustainability of salmon stocks that are wild, abundant, and healthy. Alaska’s world-famous salmon program is built on the principles of conservative management, sound science, and habitat protection. No salmon stocks of Alaska origin are listed as threatened or endangered.

Alaska’s Conservation Mandate
Successful Salmon Management, In Law and in Practice
Conservation of salmon stocks is required under the Alaska state constitution. Alaska’s constitution, unique among the 50 states, has an article solely devoted to the management and utilization of natural resources. The constitution mandates that renewable resources “shall be utilized, developed and maintained on the sustained yield principle.”

Alaska law states: “The Commissioner shall manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well being of the state through rehabilitation, enhancement, and development programs, and shall do all things necessary to insure perpetual and increasing production and use of the food resources of state waters and continental shelf areas.”

The Alaska Department of Fish and Game manages salmon fisheries, while the Alaska Board of Fisheries has responsibility for allocating the yield of salmon among users. The clear separation of management authority from allocation authority is one of the strengths of the Alaska management system. The “Sustainable Salmon Fisheries Policy” and other vital conservation management policies define the management program for protecting habitats and sustaining salmon, with priority for wild stocks.

In 1990, Alaska outlawed the farming of salmon to protect strong native stocks from hybridization, disease, pollution, and competition for food.

Alaska’s Environmental Record
Protecting Salmon Habitat
Alaska has always made a strong commitment to conserving and protecting salmon habitats. ADF&G manages salmon in over 15,000 salmon spawning streams and rivers throughout the state.

Alaska’s habitat conservation laws and regulations provide clean, free-flowing waterways vital to abundant, sustainable salmon production. There are very strict laws and regulations governing industry and development activities, such as road building, logging, and mining, to protect vital spawning and rearing salmon streams. The “Anadromous Fish Act” (AS 16.05.870) requires approval for any in-stream construction activities in salmon streams. Under Alaska’s “Forest Practices Act” (41.17.010) buffer zones are required between logging areas and salmon streams to protect spawning and rearing habitats from erosion and other problems. The Commissioner of ADF&G may also acquire water rights to protect fish. Stream flow and volume, necessary for salmon migration and propagation, are protected under the “Water Use Protection Act” (AS 46.15). In addition, Alaska’s Department of Environmental Conservation (ADEC) monitors and regulates the discharge of pollutants to ensure high water quality in both marine and fresh waters.

Alaska has been willing to forego the economic benefits from activities such as hydropower development in order to sustain salmon resources for future generations. For example, although the option of constructing and operating large-scale, hydropower facilities on both the Susitna River and the Yukon River were closely examined, neither was built. The wild salmon resource from these drainages was a major reason that Alaska chose the no-dam option.
As described in the brochure, managers have a “clear conservation mandate” and the emphasis of commercial salmon fisheries management is “to maintain adequate spawning escapements.”

Management History
Salmon Runs were not always bountiful:
Alaska did not always have healthy salmon stocks. Overfishing under federal management was a major factor in the declines of the Alaska salmon fishery that occurred between 1940 and the time of statehood, 1959. Salmon stocks and the fishing industry were in such bad shape that President Eisenhower declared Alaska a federal disaster area in 1953.

In 1959, statewide harvests totaled only about 25 million salmon - less than 20 percent of current sustained production. Over the last 20 years, sound state management with gradually increasing funding for research and management has rebuilt salmon runs from the dismal conditions inherited at statehood to the healthy levels experienced today. Alaska has been at the leading edge of salmon research.

Alaska’s Science-Based Management
Letting the Managers Manage
With the constitutional and statutory conservation mandates, the Alaska Department of Fish and Game has effectively managed Alaska’s salmon stocks to ensure conservation and to promote sustainable production. As a result, stocks of salmon spawning in Alaska are healthy, and fisheries dependent upon these stocks have benefited, with statewide harvests ranging from about 100 to 200 million salmon per year over the past 15 years.

Inseason Abundance Based Management:
State of Alaska management has been intensive, conducted on a real-time basis with regulations imposed inseason by local biologist, who have a clear conservation mandate and authority to open or close fisheries as needed.

Delegated emergency authority provides for immediate management decisions by area biologists. When runs are strong, managers liberalize harvest regulations to utilize surpluses. When runs are poor, managers close fisheries to provide for predetermined escapement needs which ensure long-term sustainable yields.

Local biologists monitor returning salmon using various methods: aerial surveys, weirs, streamside counting towers, fish wheels, sonar, test fisheries, and input from fishermen. Based on their in-season abundance count, salmon managers open and close fisheries on a daily basis to ensure spawning escapements are adequate to sustain production.

Alaska’s emphasis on in-season management to maintain adequate spawning escapements is the key ingredient to successful salmon management. This inseason abundance based management program was recently adopted by the Pacific Salmon Commission to manage and conserve salmon resources shared by Alaska, Oregon, Washington, and Canada.
British Columbia Wild Salmon Resources

After record catches in many commercial salmon fisheries during the mid-1980s, British Columbia wild salmon catches fell dramatically during the 1990s. Some stocks of coho and sockeye salmon also experienced large declines in spawning escapements during the 1990s, leading to a ban on coho fishing along the entire BC coast in 1998 and closures of directed fisheries for some sockeye stocks. Changing ocean conditions, leading to poor ocean survival, may have been key factors in this decline. More favorable ocean conditions since 1999 have led to improved ocean survival, although some specific stocks are still considered to be depressed.8

Table II-5 summarizes the status of British Columbia wild salmon stocks as described in a recent study of the British Columbia seafood industry. In general, most chinook, sockeye and pink salmon stocks are considered “healthy,” while the status of coho and chum salmon stocks is considered “mixed.”

In 2003, the Federal Species at Risk Act (SARA) obliged the Federal Minister of the Environment to take measures to protect ‘endangered’ or ‘threatened’ species. These measures include prohibitions on harming individuals or their residences, and mandatory development of recovery strategies and action plans. Three salmon species—Cultus Lake sockeye, Sakinaw Lake sockeye, and Interior Fraser River coho—were proposed to be listed as ‘endangered’ under SARA. In January 2005, the Government of Canada made a final decision not to list Cultus and Sakinaw sockeye under SARA due mainly to the large socio-economic benefits that would be foregone. As of September 2005 a listing decision on Interior Fraser coho had not been made.

Nevertheless, the threat of listing salmon species has affected and will continue to affect management of salmon fisheries in British Columbia. The result is reduced fishery opportunities in an attempt to increase spawning numbers for populations of concern.

U.S. Pacific Northwest Wild Salmon Resources

The status of U.S. Pacific Northwest salmon resources was summarized in the introduction to the 1996 National Research Council study Upstream: Salmon and Society in the Pacific Northwest:

“Wild salmon, which once numbered more than 8-10 million returning adults in the Columbia River basin alone, have declined to less than one-tenth that number up and down the coast of the Pacific Northwest. Most of the fish that now return began their lives in hatcheries . . . The decline in salmon numbers has been observed and lamented for at least a century and a half, as the human population has grown and economic activity has increased . . . More recently, petitions have been filed to list some species or populations as endangered or threatened under the Endangered Species Act; lawsuits have been filed, meetings have been held, federal laws have been passed, and more than $1 billion has been spent over the last 10 years alone to improve salmon runs in the Pacific Northwest. Despite extensive recent efforts and activities to improve conditions for salmon, their overall populations in the region continue to decline. The decline is not universal; some populations or stocks in some streams are not declining, and some in the northern part of the range are even increasing.”

<table>
<thead>
<tr>
<th>Species</th>
<th>Status</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook</td>
<td>Healthy</td>
<td>Continued improvement from late 1990s; most stocks at or above escapement goals</td>
</tr>
<tr>
<td>Coho</td>
<td>Mixed</td>
<td>Continued improvement from late 1990s, particularly in Strait of Georgia; interior Fraser River and some North and Central Coast coho remain weak</td>
</tr>
<tr>
<td>Sockeye</td>
<td>Healthy</td>
<td>Increased returns to Nass, Skeena, Barkley Sound and most Fraser River stocks; continued concerns about in-river mortalities in late Fraser River run; Sakinaw Lake, Cultus Lake, Rivers and Smith Inlet stocks depressed</td>
</tr>
<tr>
<td>Pink</td>
<td>Healthy</td>
<td>Record returns to Fraser River in 2001; localized concerns for some Central Coast and Broughton Archipelago stocks</td>
</tr>
<tr>
<td>Chum</td>
<td>Mixed</td>
<td>Generally stocks in south are strong; some North Coast stocks remain depressed</td>
</tr>
</tbody>
</table>


8 The discussion in this section is based on G.S. Gislason & Associates (2004).
The declines are “largely a result of human impacts on the environment caused by activities such as forestry, agriculture, grazing, industrial activities, urbanization, dams, hatcheries and fishing”—and are exacerbated by variations in ocean conditions.

One indicator of the long-term decline is Columbia River commercial salmon catches (Figure II-5). Commercial salmon fishing by European settlers began on the Columbia River in the 1830s, increased rapidly after the 1860s with the development of salmon canning technology, peaked in the 1880s and again in World War I at more than 40 million pounds, and then experienced a long period of decline to annual catches of less than 3 million pounds during the 1990s.

However, this graph overstates the extent of the actual decline in Columbia River salmon returns and catches, because much of the fishery for Columbia River salmon moved offshore, from in-river net fisheries to ocean troll fisheries, during the first half of the 20th century. In addition, Columbia River salmon are also caught in other salmon fisheries off the coasts of Southeast Alaska, British Columbia, Washington and Oregon—illustrating both the complexity of salmon fisheries and the difficulty of describing resource conditions and trends.

The status of individual salmon stocks varies widely across the U.S. Pacific Northwest region. For example, according to a 1992 assessment of 515 Washington salmonid stocks, 201 stocks were considered “healthy,” 124 stocks were considered “depressed,” 18 stocks were considered “critical”—while the condition of 171 stocks was “unknown” (Table II-6).

In 2004, the Endangered Species Act status of West Coast salmon and steelhead indicates that 5 of 50 evolutionarily significant units (ESU)9 are ‘endangered’ (Table II-7) (www.nwr.noaa.gov).

Efforts to rebuild stocks face daunting technical, economic and political challenges. How to rebuild U.S. Pacific Northwest salmon stocks is a complex debate of national importance which has drawn significant attention. From the point of view of commercial wild salmon fisheries, however, U.S. Pacific Northwest salmon catches are much smaller than those of Alaska, and of relatively limited and local economic significance.

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**Figure II-5** Commercial Catches of Columbia River Salmon, 1866-2000


9 An Evolutionarily Significant Unit, or “ESU,” is a distinctive group of Pacific salmon or steelhead. NOAA Fisheries considers an ESU a “species” under the Endangered Species Act (www.nwr.noaa.gov).
### Table II-6

**Classification of Washington Salmonid Stocks in 1992, by Status and Species**

<table>
<thead>
<tr>
<th>Category</th>
<th>Chinook</th>
<th>Chum</th>
<th>Coho</th>
<th>Pink</th>
<th>Sockeye</th>
<th>Steelhead</th>
<th>Bull trout/ D.Varden</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy</td>
<td>54</td>
<td>48</td>
<td>37</td>
<td>9</td>
<td>3</td>
<td>36</td>
<td>14</td>
<td>201</td>
</tr>
<tr>
<td>Depressed</td>
<td>35</td>
<td>3</td>
<td>34</td>
<td>2</td>
<td>4</td>
<td>44</td>
<td>2</td>
<td>124</td>
</tr>
<tr>
<td>Critical</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Unknown</td>
<td>14</td>
<td>18</td>
<td>18</td>
<td>2</td>
<td>1</td>
<td>60</td>
<td>58</td>
<td>171</td>
</tr>
<tr>
<td>Extinct</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>108</td>
<td>72</td>
<td>90</td>
<td>15</td>
<td>9</td>
<td>141</td>
<td>80</td>
<td>515</td>
</tr>
</tbody>
</table>


### Table II-7

**Endangered Species Act Status of West Coast Salmon and Steelhead**  
(updated March 25, 2004)

<table>
<thead>
<tr>
<th>Species</th>
<th>Evolutionarily Significant Unit (ESU)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sockeye</td>
<td>Snake River</td>
<td>Endangered</td>
</tr>
<tr>
<td></td>
<td>Ozette Lake</td>
<td>Threatened</td>
</tr>
<tr>
<td>Chinook</td>
<td>Sacramento River</td>
<td>Endangered</td>
</tr>
<tr>
<td></td>
<td>Upper Columbia River Spring run</td>
<td>Endangered</td>
</tr>
<tr>
<td></td>
<td>Snake River Spring/Summer run</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Snake River Fall run</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Puget Sound</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Lower Columbia River</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Upper Willamette River</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Central Valley Spring run</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>California Coastal</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Central Valley Fall and Late Fall run</td>
<td>Candidate</td>
</tr>
<tr>
<td>Coho</td>
<td>Central California Coastal</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Southern Oregon/Northern California</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Oregon Coast</td>
<td>Threatened/Candidate</td>
</tr>
<tr>
<td></td>
<td>Lower Columbia River/Southwest Washington</td>
<td>Candidate</td>
</tr>
<tr>
<td></td>
<td>Puget Sound/Strait of Georgia</td>
<td>Candidate</td>
</tr>
<tr>
<td>Chum</td>
<td>Hood Canal Summer run</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Columbia River</td>
<td>Threatened</td>
</tr>
<tr>
<td>Steelhead</td>
<td>Southern California</td>
<td>Endangered</td>
</tr>
<tr>
<td></td>
<td>Upper Columbia River</td>
<td>Endangered</td>
</tr>
<tr>
<td></td>
<td>Central California Coast</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>South Central California Coast</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Snake River Basin</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Lower Columbia River</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>California Central Valley</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Upper Willamette River</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Middle Columbia River</td>
<td>Threatened</td>
</tr>
<tr>
<td></td>
<td>Northern California</td>
<td>Threatened</td>
</tr>
</tbody>
</table>

Source: [www.nwr.noaa.gov/1salmon/salmesa](http://www.nwr.noaa.gov/1salmon/salmesa)
**Status of Pacific Northwest Salmon Populations**

*(as summarized in the Executive Summary of the Natural Research Council Report “Upstream: Salmon and Society in the Pacific Northwest”)*

The status of many specific salmon populations in the Pacific Northwest is uncertain, and there are exceptions to most generalizations with regard to overall status. Nevertheless, a general examination of the evidence of population declines over broad areas is helpful for understanding the current status of species with different lifecycle characteristics and geographical distributions, and with some caution, the following generalizations are justified:

*Pacific salmon have disappeared from about 40 percent of their historical breeding ranges in Washington, Oregon, Idaho, and California over the last century, and many remaining populations are severely depressed in areas where they were formerly abundant.* If the areas in which salmon are threatened or endangered are added to the areas where they are now extinct, the total area with losses is two-thirds of their previous range in the four states. Even if the estimate of population losses of about 40 percent is only a rough approximation, the status of naturally spawning salmon populations gives cause for pessimism.

*Coastal populations tend to be somewhat better off than populations inhabiting interior drainages.* Species with populations that occurred in inland sub-basins of large river systems (such as the Sacramento, Klamath, and Columbia rivers)—spring/summer Chinook, summer steelhead, and sockeye—are extinct over a greater percentage of their range than species limited primarily to coastal rivers. Salmon whose populations are stable over the greatest percentages of their range (fall Chinook, chum, pink, and winter steelhead) chiefly inhabit rivers and streams in coastal zones.

*Populations near the southern boundary of species’ ranges tend to be at greater risk than northern populations.* In general, proportionately fewer healthy populations exist in California and Oregon than in Washington and British Columbia. The reasons for this trend are complex and appear to be related to both ocean conditions and human activities.

*Species with extended freshwater rearing (up to a year)—such as spring/summer Chinook, coho, sockeye, sea-run cutthroat trout, and steelhead—are generally extinct, endangered, or threatened over a greater percentage of their ranges than species with abbreviated freshwater residence, such as fall Chinook, chum, and pink salmon.*

*In many cases, populations that are not smaller than they used to be are now composed largely or entirely of hatchery fish.* An overall estimate of the proportion of hatchery fish is not available, but several regional estimates make clear that many runs depend mainly or entirely on hatcheries.


**Northeast Wild Salmon Resources**

Historically wild Atlantic salmon were found in eastern North American rivers in New England, Quebec, the Maritime Provinces and Newfoundland. Across much of this area, Atlantic salmon populations are drastically reduced from historic levels.

In the United States, Atlantic salmon were native to nearly every major coastal river north of the Hudson River. Historically, between 300,000 and 500,000 adults returned to U.S. rivers each year. By 2000, adult populations had fallen to less than 1,000. Natural Atlantic salmon runs disappeared from southern New England rivers by the mid-1800s. According to a World Wildlife Fund assessment, Atlantic salmon are extinct in 84 percent of historically salmon-bearing rivers of New England and in critical condition in the remaining 16 percent. Atlantic salmon in Maine were listed as endangered under the federal Endangered Species Act in 2000 (NMFS 2000).

In Canada, wild Atlantic salmon populations have declined by more than 75 percent since the 1970s. In the 1970s, about 1.5 million Atlantic salmon returned to Canadian rivers. Since then returns have fallen to about 350,000 while the proportion of small salmon (grilse) has increased from about 45 percent in the 1970s to about 75 percent. In general, rivers in the north are relatively healthy whereas those in the south (New Brunswick and Nova Scotia) are in serious trouble.

In the United States, commercial harvests of Atlantic salmon were banned by 1948. In Canada, commercial

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10 Except where otherwise noted, the discussion in this section on the status of Atlantic salmon stocks is based on the World Wildlife Fund’s 2001 report *The Status of Wild Atlantic Salmon: A River by River Assessment*.

11 National Research Council (2002).
fishing for salmon in Nova Scotia, New Brunswick and the Gaspé region of Quebec was banned in 1972 and salmon fishing around Newfoundland was closed in 1992.

Numerous factors contributed to the decline of Northeast Atlantic salmon. In southern New England populations were already greatly reduced by the mid-1800s as a result of fishing, water quality degradation and barriers to migration. More recent factors include agricultural water extraction, acidification due to acid rain and increased and unexplained salmon mortality at sea.

Factors Affecting Future Commercial Wild Salmon Catches

We present four factors which may affect future commercial wild salmon catches:

- **Natural environmental variation.** Natural environmental variations, such as ocean conditions among others, cause significant short-run and long-run variation in salmon returns and thus the numbers of salmon available for harvest in commercial fisheries. This natural variation is likely to continue to affect salmon returns and catches in the future, in ways that are difficult to predict.

- **Environmental degradation and restoration.** Historically, stream blockages, pollution, changes in water flows, competition from hatchery releases and other human-caused environmental changes played a major role in the decline of once-healthy wild salmon runs in the Northeast, the U.S. Pacific Northwest, and parts of British Columbia. However, it is unlikely that these factors will result in significant further reductions in commercial catches. Where the pressures on the environment are greatest, in the Northeast and the U.S. Pacific Northwest, commercial catches have already been so reduced that they represent a relatively small part of total wild catches, and it seems unlikely that restoration efforts (as opposed to natural environmental variation) will result in large future increases in commercial catches. In contrast, most of the Alaska fisheries which today account for most North American commercial catches do not face significant environmental threats—in large part because of their remoteness—and managers are committed to conserving those resources.

- **Fishing.** Historically, over-fishing contributed to the decline in North American salmon resources. However, increasingly North American salmon managers are committed to limiting catches to sustainable levels. Over-fishing will likely continue to occur in some fisheries in some years, in part due to the practical difficulties of fishery management, and is thus likely to reduce catches in some areas. However, it seems unlikely that over-fishing will occur on a scale sufficient to cause substantial reductions in total commercial catches.

- **Market Factors.** In the short-term, changes in prices have relatively little effect on commercial catches of wild salmon. Catches cannot increase substantially when prices rise because catch levels are set by managers based on the number of fish returning. If prices are high in a given year, fishermen may fish harder—but managers do not allow them to catch more than the available surplus of fish. In contrast—and less obviously—catches do not decline substantially when prices are low. As discussed in subsequent chapters, this is because there is substantial excess fishing capacity in most commercial salmon fisheries. In most Alaska salmon fisheries, most of the available salmon have continued to be caught and processed, despite a decline in ex-vessel prices.\(^\text{12}\)

Over the longer-term, however, changes in market conditions could have a more significant effect on catches. This will be discussed in Chapters IV, XIII and XIV.

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\(^{12}\) The main exception has been in Alaska pink salmon fisheries, where low prices have in some years caused fishermen and processors to forego the opportunity to harvest and process late-season pink salmon returns in years of high abundance.
References


Alaska Department of Fish and Game. *Policy for the Management of Sustainable Salmon Fisheries* (5AAC 39.222) www.cf.adfg.state.ak.us/geninfo/pubs/pubshome.php


The Great Salmon Run: Competition Between Wild and Farmed Salmon