

The Role of Hatcheries in North American Wild Salmon Production

Key Points

- ✓ A significant share of the salmon caught by North American commercial fishermen are released from hatcheries. In recent years, hatchery fish have accounted for about 38 percent of total Alaska “wild” salmon catches, including about 40 percent of Alaska pink salmon catches and 69 percent of Alaska chum salmon catches. Most Alaska hatchery production is concentrated in Southeast Alaska and Prince William Sound. The importance is highlighted by ADF&G: “The ocean ranching program provides hundreds of Alaskans with seasonal jobs. It is now considered the largest agricultural industry in Alaska” (Farrington 2004 p. 2).
- ✓ The Alaska hatchery program faces significant economic and political challenges, including:
 - Lower economic net return due to lower prices
 - Declining state financial support for hatcheries
 - Declining direct benefits to fishermen from hatcheries as the share of catches needed to cover costs of hatchery operations increases
- Opposition from fishermen dependent on natural wild salmon catches who argue that large-scale hatchery catches has depressed ex-vessel prices they receive
- Lack of markets for “dark” hatchery fish (fish that have physiologically changed as they move back to fresh water) in some years, leading to discarding of fish carcasses after extraction of salmon roe
- Concerns about potential adverse effects of hatchery releases on Alaska natural wild salmon runs.
- ✓ There are also significant hatchery programs in British Columbia, the U.S. Pacific Northwest and California, which account for significant shares of the commercial and recreational fisheries.
- ✓ Hatcheries add another dimension of complexity and ambiguity to the discussion over environmental, economic and social issues related to wild and farmed salmon. Some of the environmental and economic issues associated with salmon farming are also associated with commercial hatchery production.

Introduction¹

It is common to think of salmon as either “wild” or “farmed.” However, not all “wild” salmon are equally wild. A large share of the salmon returning to North American streams, and a large share of the salmon caught by North American commercial fishermen, are released from hatcheries and are considered ‘ranch’ salmon. However, most discussion is framed in a ‘wild’ salmon context which includes both ‘natural wild’ and ‘ranch’.

In some ways, hatchery salmon are more like farmed salmon than natural wild salmon.²

- Like farmed salmon, hatchery salmon spend the first part of their lives in hatchery incubation

systems and/or rearing containers, eating similar kinds of feeds.

- Like those farmed salmon which escape into the natural environment, hatchery salmon may potentially affect the genetic diversity of natural wild salmon stocks. This is particularly a concern in Washington, Oregon and California.
- Like farmed salmon, hatchery salmon compete in world markets with natural wild salmon.
- Like farmed salmon, there are significant costs in producing hatchery salmon, and the extent to which hatcheries are economically viable depends upon market conditions.

¹ A good deal of the discussion of this chapter, in particular the portion on Alaska’s hatchery programs, is drawn from Knapp (1999).

² See footnote 2 in Chapter II.

Unlike farmed salmon, hatchery fish compete with natural wild fish for food. For these reasons, hatcheries add another dimension of complexity and ambiguity to the discussion over environmental, economic and social issues related to wild and farmed salmon.

Once thought of as a way to restore and enhance natural wild salmon runs, hatchery salmon are now recognized as potentially harmful to natural wild salmon runs because of genetic interactions and competition for food and habitat in freshwater and marine environments. There is an active debate among scientists, commercial fishermen and the public as to the appropriate role and scale of salmon hatcheries. This is particularly true in the U.S. Pacific Northwest.

In this chapter we review the role of hatchery salmon in North American commercial wild salmon fisheries, and the economic issues associated with hatchery salmon.

Overview of North American Hatchery Programs

Salmon hatcheries have been established in North America for many purposes including:

- Introducing salmon fisheries where none previously existed.
- Replacing or enhancing natural salmon runs which were extinct or diminished.
- Increasing abundance of salmon for sports fisheries

- Increasing abundance of salmon for commercial fisheries.

Hatcheries were first established in North America in the second half of the nineteenth century, motivated by the recognition that natural stocks of salmonids were in decline and the desire to introduce salmon and trout outside their native ranges (Thorpe 1980). The first hatchery propagation of Pacific salmon (*Oncorhynchus* spp.) took place in Canada in 1857 (Bardach et al. 1972). Soon after, salmon hatchery techniques were adopted in the United States. The first U.S. hatchery was opened in 1864 in New York State to raise brook trout (Calabi 1990). However, hatchery-based enhancement programs were introduced at a significant scale only after the 1950s. Hatcheries were introduced to Japan in 1877.

More than two billion Pacific salmon were released in 2000 by North American salmon hatcheries (Table IV-1). Alaska accounted for 69 percent of total releases, while Canada and the U.S. Pacific Northwest each accounted for about 16 percent (Table IV-2).

Alaska releases were mostly pink and chum salmon, western Canadian releases (mostly British Columbia) were mostly sockeye, chum and chinook salmon and U.S. Pacific Northwest releases were mostly chinook and coho salmon. Alaska accounted for the largest share of pink and chum salmon releases; Canada accounted for the largest share of sockeye releases, and the U.S. Pacific Northwest accounted for the largest share of chinook and coho releases (Table IV-2).

		Chinook	Sockeye	Coho	Pink	Chum	Total
Alaska		9.2	59.8	19.3	879.7	507.7	1479.7
Canada	Yukon	0.2	0.0	0.0	0.0	0.0	0.2
	Queen Charlotte	0.2	0.0	1.3	0.0	22.2	23.7
	North Coast	4.3	90.5	1.6	0.2	12.7	109.3
	West Coast Vancouver Island	17.5	0.0	2.7	0.0	31.8	51.9
	South Coast	29.2	39.3	14.8	16.9	30.6	130.7
	Interior B.C.	2.2	19.2	0.7	0.0	0.0	22.1
	Canada Total	53.5	148.9	21.1	17.0	97.3	337.9
Pacific Northwest	Washington	117.4	16.9	43.9	1.6	38.8	229.5
	Oregon	32.3	0.0	8.7	0.0	0.0	46.8
	California	43.8	0.0	0.6	0.0	0.0	46.8
	Idaho	6.8	0.1	0.5	0.0	0.0	15.3
	Pacific Northwest Total	200.3	17.0	53.7	1.6	38.8	338.4
TOTAL		263.0	225.7	94.2	898.4	643.8	2156.0

Source: North Pacific Anadromous Fish Commission, NPAFC Hatchery Release Data.

Note: Includes all juvenile salmon releases.

Table IV-2		Share of Salmon Fry Releases, by Region and Species, 2000				
	Chinook	Sockeye	Coho	Pink	Chum	Total
Alaska	3%	26%	21%	98%	79%	69%
Canada	20%	66%	22%	2%	15%	16%
Pacific Northwest	76%	8%	57%	0%	6%	16%
Total	100%	100%	100%	100%	100%	100%

Source: NPAFC Hatchery Release Data

Table IV-3		Number of Fry Released per Kilogram of Commercial Catches, 1997-2001				
	Chinook	Sockeye	Coho	Pink	Chum	Total
Alaska	2.3	0.7	1.5	5.5	6.3	4.3
Canada	53.4	18.3	115.6	2.3	15.3	14.2
Pacific Northwest	52.1	15.8	42.1	1.8	16.2	34.9

Note: Calculated by dividing average fry releases for the period 1997-2001 (thousands of fish) by average commercial catches for the period 1997-2001 (thousands of kilograms). For the Pacific Northwest, average fry releases for the period 1997-2000 were used because 2001 data were not available.

Table IV-3 provides a general indicator of the relative scale of hatchery releases in comparison to commercial harvests. For chinook, sockeye and coho salmon, hatchery releases per kilogram of commercial catches were much higher in Canada and the U.S. Pacific Northwest than in Alaska—suggesting that commercial fisheries for these species are relatively more dependent on hatcheries in Canada and the U.S. Pacific Northwest than Alaska. For pink and chum salmon, hatchery releases per kilogram of commercial catches were much more comparable among the three regions.

The Hatchery Process

The production of salmon in hatcheries recreates the early portion of the life cycle of the species in a protected environment (Willoughby 1999). Salmon hatcheries consist of both a freshwater and a marine phase. The freshwater phase encompasses the spawning cycle, egg production, hatching and first-feeding stages. As the fry develop, they turn into fingerlings (or parr as the Europeans tend to call them), and finally grow to become smolts. At this point the fish have become physiologically adapted to seawater conditions.

- **Broodstock management:** Broodstock are the fish from which the eggs and milt (sperm) are taken. Selection of the broodstock from adults returning to the hatchery has changed significantly over time. Until recently, little concern was given to such things as managing to maintain the genetic integrity of a river's native salmon. In recent years, scientists have determined that these needs must be addressed and have prescribed methods to choose broodstock in a more careful manner (National Research Council 1996).

- **The hatchery:** The hatchery phase is probably the most technically demanding, requiring a high degree of organization and planning. The objective of this portion of the cycle is to fertilize and hatch the eggs then raise the fry until release to open water. After hatching, the young fish feed on the contents of their yolk sac for several weeks and are called yolk-sac fry or alevins. A short time after hatching the yolk sac has been almost totally consumed and the alevins are generally developed enough to start feeding. Starter diets formulated with feed ingredients, such as fishmeals and fish oils, give rapid growth.
- **Fry and fingerling development:** When the alevins begin to feed they are known as fry. During this phase, growth is rapid. As they develop, fry become more accustomed to solid feed and increase their activity. When the fry are sufficiently developed, they are transferred into larger tanks. Once the fry reach an average weight of about 5 g, they are known as *fingerlings*.
- **Smolt production:** Once the larger fingerlings are sufficiently developed, they will undergo major physical and physiological changes to become smolts. These changes mark the transformation from a freshwater fingerling to a seawater fish (Fitzgerald et al. 2002). The smoltification process involves changes in most organ systems, morphological (silvery color), physiological (ATPase activity) and behavioral (swimming with the current), which will allow the fish to survive, grow and develop normally in the marine environment.

Hatcheries managed for stock enhancement of the commercial and sport fisheries, generally release fish to

the open water at either the fry, fingerling or smolt stage depending on species and management objectives. Pink and chum salmon are generally released at the fry stage with a large number of fry released. In British Columbia, the U.S. Pacific Northwest, where the purpose of the hatcheries are generally to ensure the survival of the stock, species such as chinook, coho and sockeye are released as smolts to increase the probability of survival in the wild.

The Alaska Salmon Enhancement Program

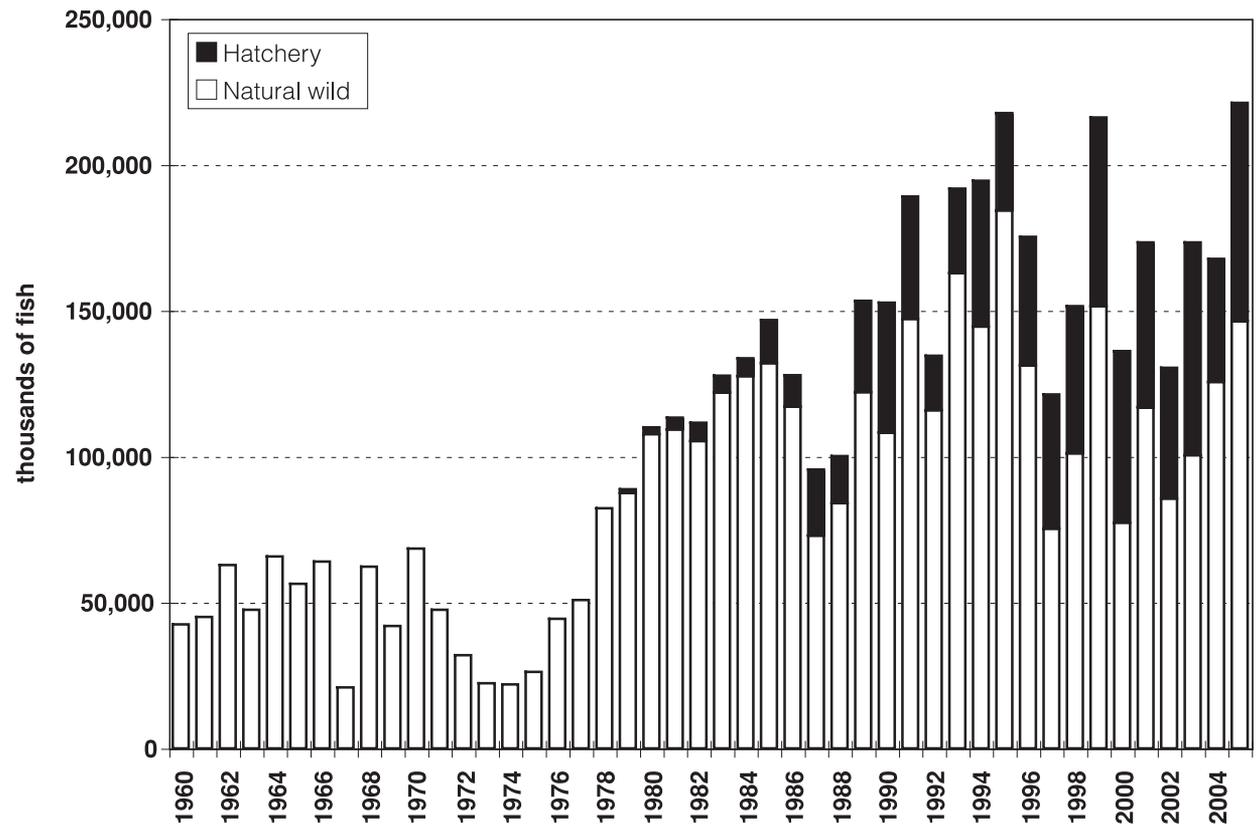
Beginning in the 1970s, the State of Alaska supported the development of numerous salmon hatcheries, with the goal of increasing and stabilizing Alaska salmon returns.³ State support of the Alaska salmon enhancement program was linked to the rapid rise in Alaska oil revenues following the discovery and

development of oil on Alaska’s North Slope. The State supported hatchery development by loaning money to private non-profit organizations for hatchery construction and operation, as well as by building and operating State-owned hatcheries which were later transferred to private non-profit regional aquaculture associations.

Beginning in the 1980s catches of both hatchery salmon and natural wild salmon increased rapidly. In 2002, the total catch of hatchery fish was 45 million salmon, about one-third of the total Alaska salmon catch (Figure IV-1).⁴

The relative importance of hatcheries varies between different Alaska salmon species. During the period 2000-2002, hatchery fish accounted for 69 percent of Alaska chum salmon catches, 40 percent of pink salmon catches and 12 percent of catches of other species (Table IV-2). Hatchery fish accounted for about

Figure IV-1 Alaska Commercial Salmon Catches Since 1960: Natural Wild Salmon and Hatchery Salmon



Source: Data for 1960-1978: ADFG Catch Data 1878-1981; Data for 1979-2005: ADFG Hatchery Data

³ The Alaska Department of Fish and Game’s annual reports on the Alaska Salmon Enhancement Program, available at www.cf.adfg.state.ak.us/geninfo/enhance/enhance.php, provide detailed information about the program.

⁴ Hatchery fish are identified in several ways, including coded wire tags, fin clips and otolith marking (a process by which an identifiable microscopic colored ring sequence in fish ear bones is created by exposing fish to a series of planned temperature changes).

28 percent of the total ex-vessel value of Alaska catches. The importance is highlighted by ADF&G: “The ocean ranching program provides hundreds of Alaskans with seasonal jobs. It is now considered the largest agricultural industry in Alaska” (Farrington, C., ADF&G, 2004 p. 2).

The relative importance of hatcheries also varies between different areas of Alaska. In 2002, Southeast Alaska and Prince William Sound accounted for about 80 percent of hatchery catches (Table IV-4).

Certain Alaska fisheries are overwhelmingly dependent on hatchery salmon, including the Southeast Alaska chum salmon fishery, the Prince William Sound chum salmon fishery and the Prince William Sound pink salmon fishery. In other major fisheries, such as western Alaska sockeye salmon fisheries and the southeast Alaska pink salmon fishery, hatchery fish account for only a small share of total catches. Note that the two highest value species, chinook and sockeye, are less dependent on hatcheries. Part of the explanation is the health of the natural sockeye stocks in Alaska, and the relatively high cost and time it takes to raise chinook smolts.

Although hatcheries have clearly increased Alaska salmon catches, they have not stabilized catches. Salmon catches by region and in the state as a whole still vary greatly from year to year, even with hatchery programs, because hatchery fish are subject to the same ocean conditions as wild salmon. This is illustrated in Figure IV-2. During the period 1990-2005, Alaska hatchery releases of pink salmon were relatively stable, ranging between 800 million and 1 billion fish. During the same period, returns of Alaska hatchery pink salmon ranged from 15 million to 69 million fish. The percentage of fish returning varied from 1.7 percent to 7.2 percent.

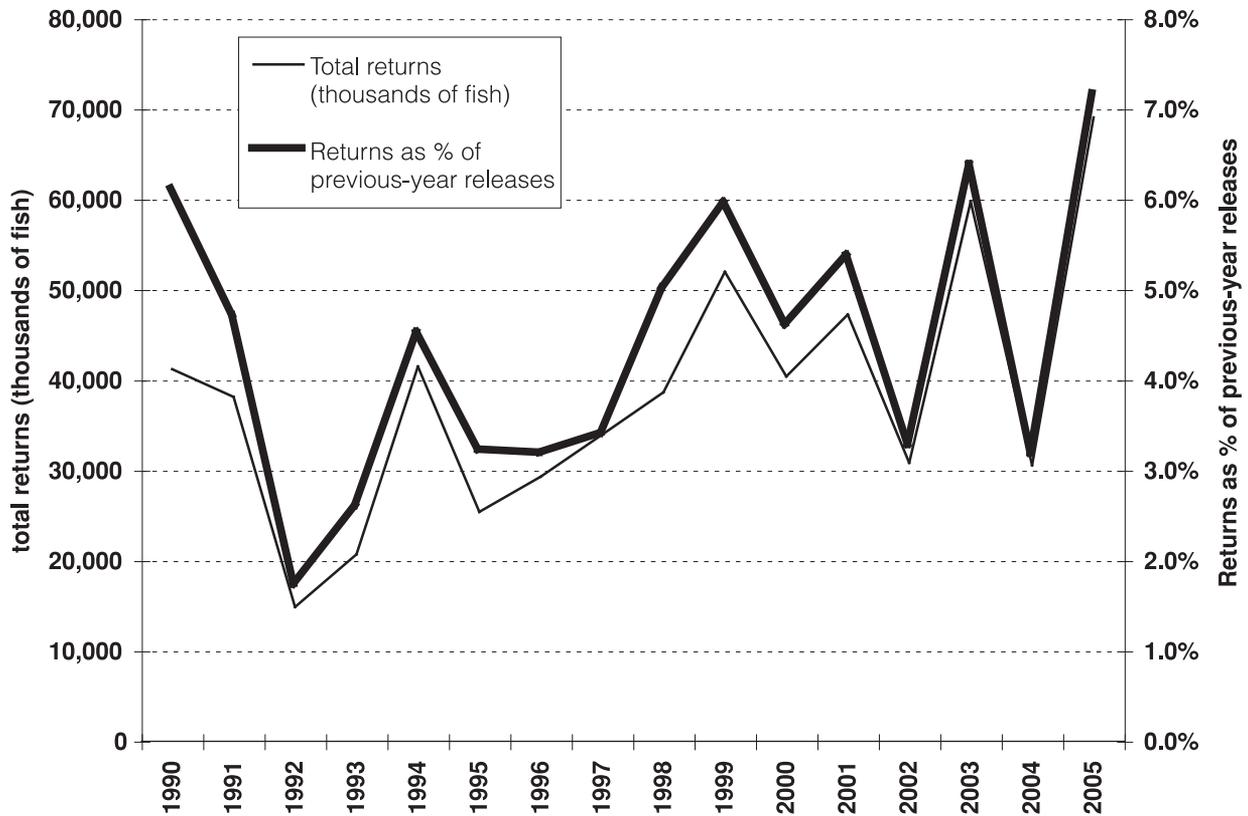
Large numbers of hatchery fish are caught by commercial fishermen prior to their return to the hatcheries. Near hatchery sites, boats hired by the hatchery catch additional large numbers of fish in the so-called ‘cost recovery’ fishery. All the proceeds from this fishery go to the hatchery. Any remaining hatchery fish are left to mill around the hatchery and die. They are not ‘programmed’ with a stream in mind to return to. Although some may stray may find a stream and spawn in it, this is neither intended nor desired.

Table IV-4		Alaska Salmon Catches by Species and Region, Hatchery & Total, 2002					
	Area	Chinook	Sockeye	Coho	Pink	Chum	Total
Commercial catches of hatchery fish (000 fish)	Southeast	87	120	1,425	1,924	5,617	9,173
	Prince William Sound	0	1,164	36	18,772	6,112	26,084
	All other areas	1	1,466	217	7,747	88	9,519
	Alaska total	88	2,750	1,678	28,443	11,817	44,776
Share of total hatchery catches, by species	Southeast	1%	1%	16%	21%	61%	100%
	Prince William Sound	0%	4%	0%	72%	23%	100%
	All other areas	0%	15%	2%	81%	1%	100%
	Alaska total	0%	6%	4%	64%	26%	100%
Share of total hatchery catches, by area	Southeast	99%	4%	85%	7%	48%	20%
	Prince William Sound	0%	42%	2%	66%	52%	58%
	All other areas	1%	53%	13%	27%	1%	21%
	Alaska total	100%	100%	100%	100%	100%	100%
Total commercial catches (000 fish)	Southeast	372	787	2,986	45,612	6,294	56,051
	Prince William Sound	40	2,262	650	18,950	6,373	28,275
	All other areas	128	19,438	1,135	23,000	2,357	46,058
	Alaska total	540	22,487	4,771	87,562	15,024	130,384
Hatchery share of commercial catches	Southeast	23%	15%	48%	4%	89%	16%
	Prince William Sound	0%	51%	6%	99%	96%	92%
	All other areas	1%	8%	19%	34%	4%	21%
	Alaska total	16%	12%	35%	32%	79%	34%

Source: ADFG Hatchery Data.

Figure IV-2

Estimated Returns of Alaska Hatchery Pink Salmon, 1990-2005



Source: ADFG Hatchery Data.

Challenges for the Alaska Salmon Enhancement Program

The Alaska Salmon Enhancement Program consists of a variety of public and private sector salmon rehabilitation and enhancement projects. In 2002, these included 29 non-profit corporation hatcheries (by far the most significant component of the program), two state-operated hatcheries, two Federal or Bureau of Indian Affairs hatcheries and several streamside incubation and restoration projects (Farrington 2003).

The Alaska Salmon Enhancement Program has clearly succeeded in increasing total salmon catches, particularly in Southeast Alaska and Prince William Sound. However, the program faces a number of challenges which could affect the future scale of hatchery releases and thus total Alaska salmon catches, particularly of pink and chum salmon. Below, we briefly review these challenges.

Lower Prices

A fundamental problem for the Alaska Salmon Enhancement Program is that real (inflation-adjusted) prices have declined significantly since the start of the program, in particular for chum and pink salmon

(Figure IV-3). As a result, investing in raising and releasing young salmon results in less of an increase in future catch value, for any given rate of ocean survival.

In theory, we might expect that as prices decline the net economic benefits of hatcheries would decline, and at some point total hatchery releases would begin to decline. However, this has not yet happened to any significant extent. Hatchery releases of pink and chum salmon stopped growing in the mid-1990s, but have not shown any significant decline (Figure IV-4).

In order to understand the relationship between salmon prices and hatchery releases, we must review the structure of hatchery operations and how they are financed. Most salmon hatcheries in Alaska are now operated by private non-profit (PNP) organizations, most of which received initial funding from state grants and capital and operating loans, to be repaid from hatchery revenues. There are two categories of PNP organizations: independent PNPs and regional aquaculture associations.

Hatcheries may earn revenues to cover operating expenses and repay state loans in two ways. First, hatcheries are authorized to catch a percentage of the adult salmon returning to terminal “special harvest

areas” for sale. These are referred to as “cost-recovery” catches.” Typically cost-recovery fish are caught by just a few boats, catching very large volumes, working under contract to the hatcheries in the special harvest areas. All other returning hatchery salmon are caught in “common-property fisheries” by commercial, sport and subsistence fishermen.

Second, in management areas with regional aquaculture associations, fishermen may vote to assess an “enhancement tax” on the ex-vessel value of their salmon landings. These enhancement tax funds also support hatchery operations. Enhancement tax rates are presently 3 percent in southeast Alaska and 2 percent in Prince William Sound, Cook Inlet and Kodiak. No enhancement taxes are assessed in other areas.

As ex-vessel prices have declined, enhancement tax collections have declined, so that the hatcheries have had to rely on cost-recovery catches for a greater share of their revenues. In addition, because prices are lower, hatcheries need to catch more fish in the cost-recovery fisheries to meet any given revenue target. As a result, as prices decline an increasing share of the hatchery returns have been caught in cost-recovery fisheries rather than by commercial fishermen in the common property fisheries. This trend is particularly evident for chum salmon, for which the cost-recovery share of catches increased from less than 30 percent in the early

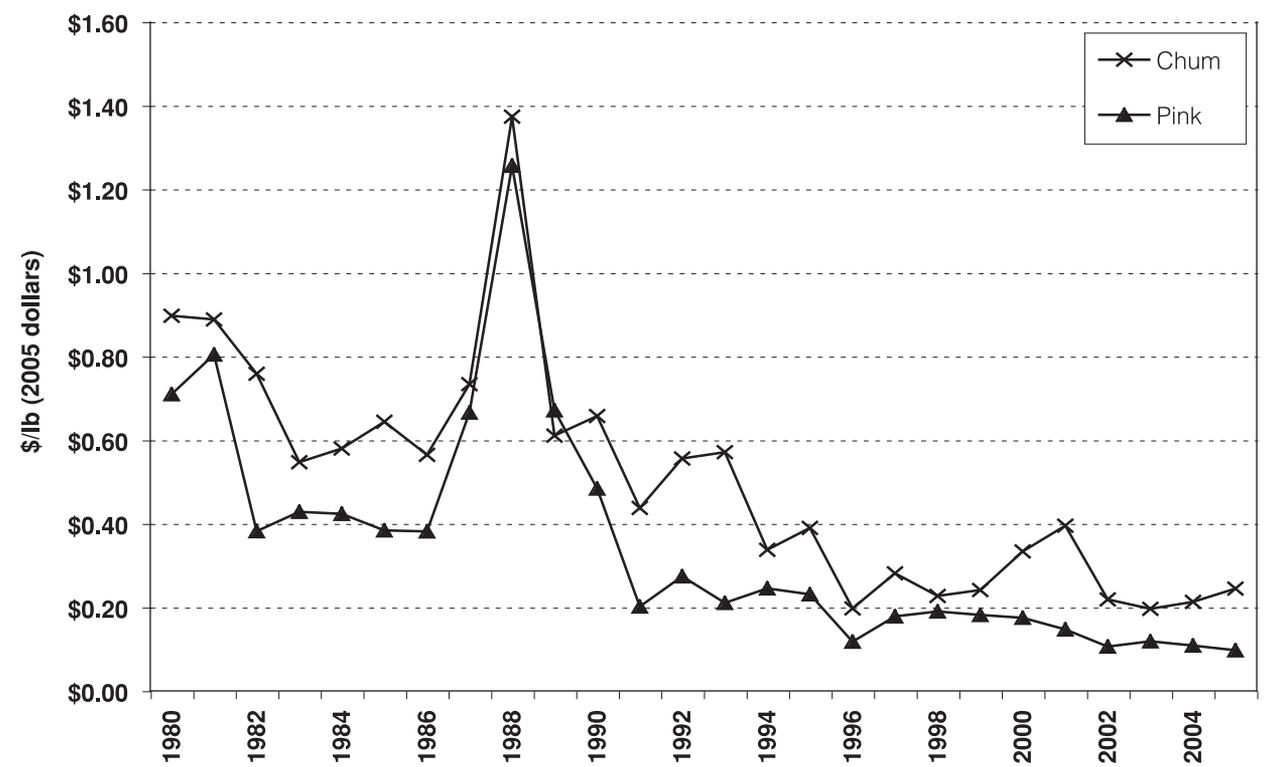
1990s to more than 51 percent in 2003 (Figure IV-5).

As the cost-recovery share of hatchery catches increases, the share of the benefits captured by commercial fishermen (other than those few who participate in the cost-recovery fishing) declines. Put differently, an increasing share of the fish goes to support the hatcheries, rather than the original concept of increasing the total volume of fish available to all fishermen.

Increasing the share of hatchery fish going to cost-recovery harvests has allowed the hatcheries to continue to operate despite lower salmon prices. However, over time, this may create a political problem for the hatcheries, which depend upon enhancement taxes paid by fishermen on all catches—not just catches of hatchery fish—and which also depend upon the political support of commercial fishermen to address other issues which they face (discussed below).

In addition to covering their operating costs, hatcheries also need to make payments on the loans they have received from the State of Alaska’s Fisheries Enhancement Revolving Loan Fund. During the early 1990s, as ex-vessel prices declined, many hatcheries requested and received permission to reschedule loan repayments. As Alaska’s oil revenues have declined, the State is less likely to extend this kind of assistance should hatcheries face financial difficulties in the future.

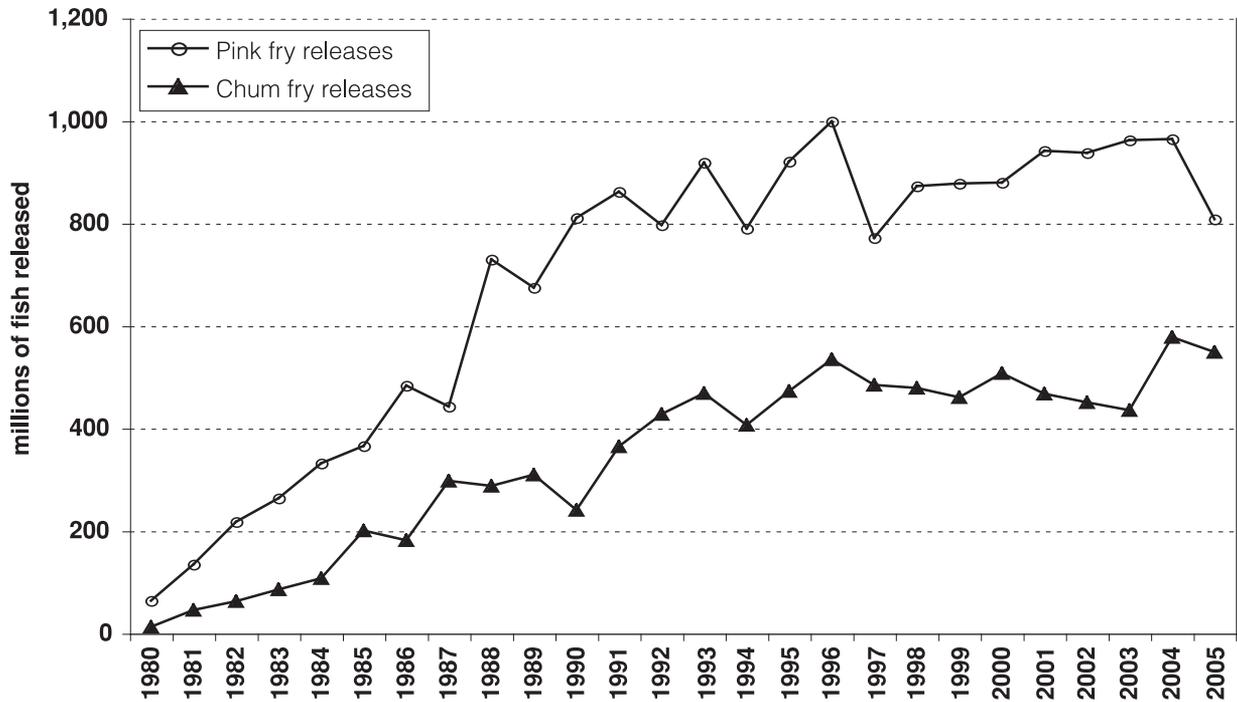
Figure IV-3 Average Real Ex-Vessel Prices for Alaska Chum and Pink Salmon, 1980-2005



Source: ADFG Catch data. Adjusted for inflation based on Anchorage CPI.

Figure IV-4

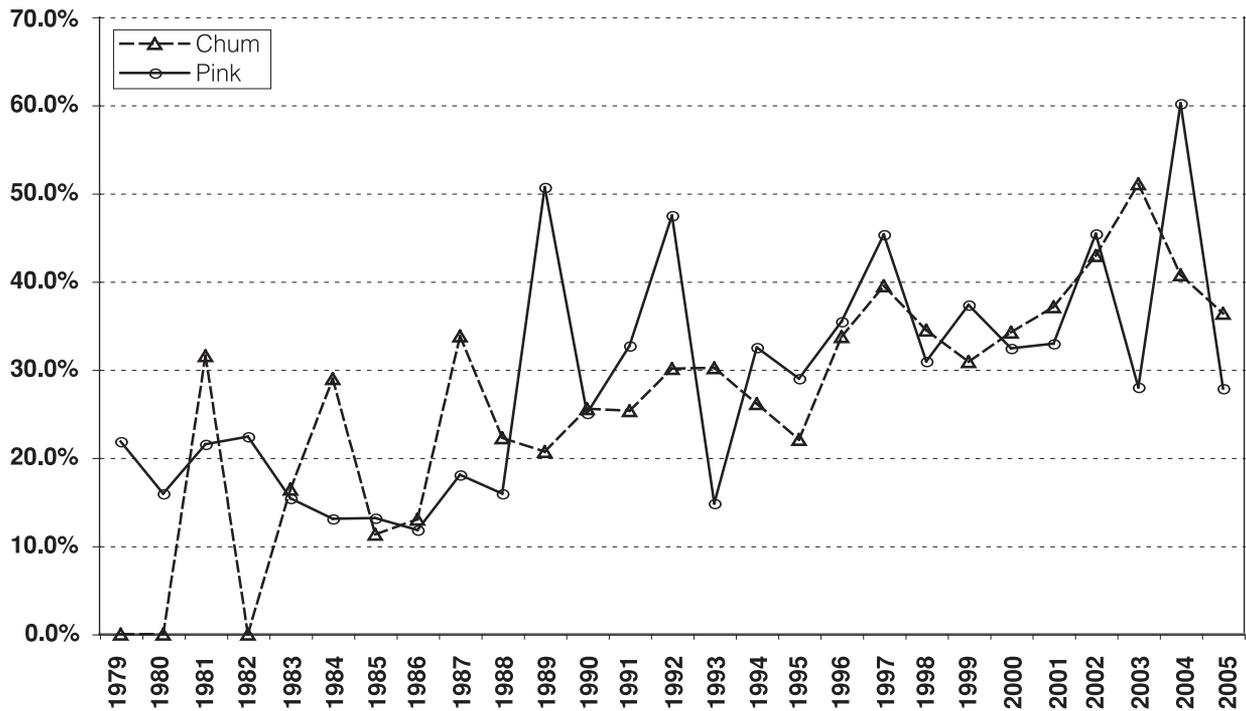
Alaska Hatchery Releases of Pink and Chum Salmon Fry, 1980-2005



Source: ADFG Hatchery Data.

Figure IV-5

Hatchery Cost-Recovery Share of Alaska Hatchery Salmon Catches



Source: ADFG Hatchery Data.

Market Effects of Hatchery Production

As we discuss in future chapters, salmon prices are sensitive to total salmon supply.

During the 1990s, fishermen in regions of Alaska without hatchery production—in particular areas of interior and western Alaska dependent on chum salmon—argued that increased hatchery catches were responsible for the disastrous decline in prices which they had experienced. More generally, the question began to be raised whether Alaska salmon hatcheries were actually increasing the total value of Alaska salmon catches, or whether the value of the increased harvests was being offset by corresponding negative effects on prices.

How much Alaska hatchery catches may have depressed Alaska salmon prices, or whether or not hatcheries have actually increased the total ex-vessel value of Alaska salmon catches (not to mention net economic value after subtracting costs of hatchery operations) is not an easy question to answer. As we discuss in subsequent chapters, salmon markets are complex and are affected by many factors. In addition, they are subject to structural change, so that the effects of a given volume of hatchery catches on prices may have changed over time.⁵

In the short-term, higher catches in a given region in any given year tend to lower ex-vessel prices in that year. Over the longer term, prices are driven by world supply and demand rather than supply and demand from any particular region. If, as with hatchery production, other regions have the ability to respond to higher prices by increasing production, then higher or lower production by a particular region will not necessarily affect long-term world prices.

In general, it seems likely that Alaska hatchery production has had some negative effects on ex-vessel prices of chum and pink salmon, but that hatcheries are not the only factor contributing to lower prices. Clearly, hatcheries have benefited fishermen and processors in some areas (primarily Prince William Sound and Southeast Alaska) by greatly increasing catches. At the same time, hatcheries have not benefited, and may well have harmed, fishermen and processors in other areas without hatchery production. Thus, the Alaska salmon hatchery program has at times been an issue between different regions of Alaska.⁶

Roe “Stripping” or “Salvaging”

A particularly contentious issue associated with the Alaska salmon hatchery program has arisen as a result

of declining prices for fresh, frozen and canned salmon while prices for salmon roe have remained strong. In some years the value of fresh, frozen and canned products have fallen below the costs of processing, particularly for lower-quality “dark” salmon caught in hatchery terminal areas after they have begun to undergo physiological changes associated with return to fresh water, and when unexpectedly large returns exceed local processing capacity. For these fish, the most economically profitable utilization is to extract the salmon roe but to dispose of the salmon carcass.

Normally, it is illegal to dispose of salmon harvested in Alaska without utilizing the fish, under a State law which bans the “waste” of commercially harvested fish. However, in some years hatcheries and processors have applied for exemptions from this law and have received permission to grind up and dispose of salmon carcasses at sea, after first removing valuable salmon roe. This practice is commonly referred to as “roe-stripping” or “roe-salvaging” depending on one’s perspective on it.

This “dumping” of salmon has been strongly criticized by some segments of the Alaska salmon industry and the public who have argued that it is immoral to waste fish and that the “stripped” or “salvaged” roe competes unfairly with other roe production. Others have responded that utilizing the valuable salmon roe is better than the alternative of not harvesting the fish at all, in particular since returning hatchery fish provide no ecological benefit and large volumes of dead fish in hatchery terminal areas would pollute these areas.

One example of this issue occurred during the 2003 pink salmon season in Prince William Sound, when 49 million pink salmon were caught after a preseason harvest projection of 27 million fish. More than 4 million pink salmon (about 8 percent of the Prince William Sound pink salmon catch and about 3 percent of the total Alaska pink salmon catch) were ground and “recycled” after the eggs were removed (Tkacz 2003).

When low prices or lack of processing capacity lead to the disposal of hatchery fish after roe extraction, it usually contributes to adverse publicity for the salmon hatchery program and questioning whether the hatchery production is needed—adding to the other political issues faced by hatcheries.⁷

Effects of Hatcheries on Alaska Natural Wild Salmon

To minimize potential adverse effects of hatchery releases on natural wild runs, the State has established an extensive regional planning process for salmon enhancement and set strict conditions for egg collection, fish transport and release and management

⁵ Market effects of the Alaska hatchery program were addressed by Boyce et al. (1993) and Herrmann (1993). These analyses were critiqued by Wilen (1993).

⁶ A different market-related issue is whether hatchery sales of cost-recovery catches may depress prices paid to local fishermen for both hatchery and natural wild fish caught in common-property fisheries.

⁷ In an *Anchorage Daily News* article, a Prince William Sound fisherman who is a former chairman of the Alaska Seafood Marketing Institute was quoted as commenting: “It’s just disappointing. . . We’ve got the mother of all runs, and we can’t sell all of the fish. I’m worried. I’m worried that some fishermen and legislators in other areas might think it’s a mistake to be generating these pink salmon, but we’re pretty grateful for them around here for all the opportunity they create. Nobody anticipated this kind of return. We should not do anything knee-jerk about occasionally having overproduction.” (Loy 2003).

of enhanced stocks. Hatcheries may only use eggs collected originally from local wild salmon stocks.⁸

However, as in other areas, some critics still question whether the Alaska salmon hatchery program may adversely affect Alaska's natural wild salmon runs. One concern relates to the potential for competition for food between hatchery salmon and natural wild salmon, both for juvenile fish in near-shore waters as well as in the open ocean.

Another set of issues relate to the management of commercial fisheries in which fishermen are catching mixed stocks of hatchery and natural wild salmon. If large returns of hatchery fish are mixed with depleted runs of natural wild fish, there is the potential for over-harvests of natural wild fish runs.

Another concern relates to the "straying" of returning hatchery fish into streams with natural runs of wild salmon, with the potential for genetic change in the natural wild salmon populations. For all of these concerns, the scientific complexity of the issues, together with lack of data and research, makes it difficult to determine how serious the potential problems associated with the hatchery program may or may not be.⁹

"Wild" Image of Alaska Salmon

An issue which may grow in importance over time is the effect of Alaska's salmon hatchery program on the "wild" image of Alaska salmon fisheries. The salmon farming industry has been subject to growing criticism over alleged adverse environmental effects as well as market effects on wild salmon fisheries. As we discuss in later chapters, the argument has been made that because of these alleged adverse effects of farmed salmon, consumers should favor wild salmon over farmed salmon. Over time, some salmon farmers may respond to these criticisms by pointing out problems associated with wild salmon. One response is likely to be that not all Alaska salmon are fully "wild," and that there are environmental and market issues associated with hatchery salmon as well as farmed salmon.¹⁰ If this caused Alaska's hatchery program to become a

concern for some consumers in the future, it could possibly reduce political support within Alaska for the hatchery program.

It should be noted that Alaska chum salmon, which account for by far the largest share of United States consumption of fresh and frozen Alaska wild salmon, is also the species most dependent on the Alaska hatchery program.

The Future of the Alaska Salmon Enhancement Program

The issues discussed above are the subject of an intense and long-running political debate about the Alaska salmon hatchery program, between supporters of the program and those who argue for substantially scaling back hatchery releases. The debate is not widely understood outside of Alaska or the salmon industry.

A series of special studies and task forces and special studies have examined the issues related to hatcheries, and at various times proposals to limit hatchery production have been debated before the Board of Fisheries. In 1991, a committee of the Alaska Senate undertook a special review of fisheries enhancement in Alaska, in order to "assemble and analyze information about the program and the global context in which it operates," and to "serve as the first step in ensuring that current and future enhancement efforts will be economically and biologically sound, while fulfilling the goals for which the program was established" (Alaska State Senate 1992). In 1996, a "Hatchery Policy Group" was appointed to review and make recommendations on state-wide hatchery production policy and hatchery loan policy (Gardiner 1996). In 2002, the Alaska legislature established a Joint Legislative Salmon Industry Task Force to review issues facing the salmon industry and make recommendations to the legislature. The Task Force formed a number of subcommittees, including a "Hatchery Subcommittee" which was charged with examining Alaska hatchery policy issues.¹¹

⁸ See McGee (1995) for a useful review of the planning process and state policies related to the hatchery program and protection of wild salmon.

⁹ These concerns were summarized in Environment and Natural Resources Institute (2001): "Alaska's ocean-ranching salmon hatcheries operate amidst considerable uncertainty. Perhaps the most striking feature uncovered by this review was the many gaps in the scientific data from which one could fairly draw conclusions of the effects hatcheries may or may not have on wild salmon. Alaska has been successful in augmenting salmon harvest with hatchery-produced fish, but whether or not salmon biodiversity has been adequately protected in the process is unanswered. . . . With respect to fish-culture practices, Alaska's hatcheries are among the best in North America. . . . Given the late date at which Alaska's ocean-ranching program was established, the state was able to benefit from mistakes made elsewhere. The program started on better footing by having genetic oversight of operations through fish transport permits, hatchery siting, egg takes, broodstock development, etc." Nevertheless, the report concluded that, as a result of mixed-stock management issues, competition for resources between hatchery and wild salmon stocks, and potential effects on genetic diversity of wild salmon populations, "industrial-scale hatchery salmon production . . . could be jeopardizing Alaska's wild salmon."

¹⁰ Dodd (2003) suggested that "the fish which the hatcheries produce for commercial fishermen undoubtedly eat sizeable quantities of prey species as they move up the feed chain towards harvest time, prey that would otherwise be available to truly 'wild' fish." Another example is provided by an article posted on the website of the Washington Fish Growers Association (www.wfga.net): "Salmon farming vs. salmon ranching is another interesting issue that likely doesn't make its way into the 'wild is good, farmed is bad' marketing campaign. In order to help maintain its commercial fishery, and enhance wild fish stocks, Alaska decided to forego the salmon farming route and do salmon ranching instead. Salmon ranching is a lot like salmon farming. Fish are raised in ocean-based pens, fed a steady diet of processed food (purchased in British Columbia, interestingly enough, and consumed at nearly six times the rate used in British Columbia fish-farm operations), fed some dyes important to their health and colour, also antibiotics. When they're big enough, they let them go. Alaska releases more than 1.5 billion "ranching" fish into the waters every year, and they happily swim away, competing for food with their natural-born cousins, and eventually get caught (along with the wild fish) in the commercial fishery. . . ."

¹¹ Information about the activities of the Task Force, including proposed legislation developed by the task force, was posted on the website of the United Fishermen of Alaska, at www.ufa-fish.org/taskforce/.

Earlier task forces and studies have not resulted in major changes to the Alaska's hatchery program policies or the scale of hatchery releases. However, the underlying political issues remain and the debate over the program continues, even expanding into new fora. With the Marine Stewardship Council's (MSC) certification of the Alaska salmon fishery as a sustainable fishery (see Chapter XVI for a more thorough discussion), one of the concerns brought up in the certification process in 2000-2001 was the hatchery program. In particular, the assessment team was concerned about the lack of research on the potential effects of salmon hatcheries on the wild stock gene pool and reproductive fitness (Scientific Certification Systems 2000). This concern remained in 2005 as the Alaska salmon fishery entered its new five-year assessment for re-certification under the MSC program.

It is possible that Alaska hatchery salmon releases and catches could decline significantly in the future due to lower economic return of hatcheries and/or changing political circumstances. It is difficult to predict whether such a decline will in fact occur or when it might occur. It could be that hatchery salmon—as opposed to natural wild salmon—would be most affected by changing economic circumstances in wild fisheries.

The British Columbia Salmonid Enhancement Program

In 1977, in response to declining British Columbia salmon runs, the Canadian federal Department of Fisheries and Oceans (DFO) launched a Salmonid Enhancement Program (SEP). The program included both the construction of hatchery facilities as well as a variety of other habitat enhancement projects such as spawning channels, incubation boxes and lake enrichment.

DFO estimates that about 10-20 percent of the British Columbia sport and commercial salmon catch originates from SEP projects, and about a dozen terminal fisheries are dependent on enhanced stocks (DFO 2000a). A terminal fishery is one that occurs at the place where the hatchery salmon were released into fresh water.

In a 2000 review of the Salmonid Enhancement Program, the Pacific Fisheries Resource Conservation Council (PFRCC 2000; DFO 2000b) concluded that:

In hindsight, it is difficult to say whether the Salmonid Enhancement Program and its predecessors, which have accounted for close to a half-billion dollars in public investments over the years, have produced any net return on investment, if measured by a net gain of salmon. There is evidence to suggest a net loss of wild salmon abundance, directly and indirectly because of enhancement initiatives. . .

The Council's review of the Salmonid Enhancement Program leads inevitably to the conclusion that

some facilities created by it have resulted in the displacement of wild salmon by hatchery-produced fish. This has occurred when hatchery salmon have attracted fishing effort that unavoidably produced unsustainably high rates of harvest on co-migrating wild salmon. It has also occurred because juvenile fish from wild populations have been subjected to competition from hatchery fish in rearing areas, and in the ocean phase of the salmon life cycle.

Declines in numerous wild-salmon populations, concurrent with increases in production from a few large hatcheries, tend to create a situation in which salmon abundance is attributable to ever-fewer stocks. This places the salmon resource at an increasingly greater risk of random, catastrophic disruption.

History of Salmon Hatcheries in the U.S. Pacific Northwest

Hatchery techniques for the artificial propagation of Pacific salmon were developed for the first time in Canada around 1857 and soon spread to the United States (Bardach et al. 1972).

The construction and operation of the first hatcheries for Pacific salmon in the United States began on the McCloud River in northern California in 1872 and in 1877 and 1878 on the Clackamas and Rogue Rivers in Oregon (Atkinson 1988). In 1883, the first Canadian hatchery for Pacific salmon was built at Bon Accord (near New Westminster, British Columbia) on the Fraser River (PCSF 2004). The first hatchery in Washington State was built on the Kalama River in 1895 (WDFW 2004). Four years later, the Washington Department of Fish and Wildlife began the construction of salmon hatcheries in the mid-Columbia River region, on the Wenatchee and Methow Rivers (Wahle and Pearson 1984).

Hatcheries were originally built to reverse the trend of declining populations of wild salmon and to compensate for land use decisions that permanently altered large areas of fish habitat (WDFW 2004). Emphasis was initially placed on chinook and coho salmon despite an incomplete understanding of the complex life history of these species. Hatcheries propagated and stocked salmon for many years without concrete evidence of the success and long-term implications of their efforts.

Large-scale construction of salmon hatcheries began in 1938, when Congress passed the Mitchell Act to provide federal money for construction of hatcheries as a way of replacing the thousands of acres of salmon spawning grounds that were blocked or flooded behind dams. Subsequently, more than 80 hatcheries were built in the Columbia River basin (Novak 1998).

Currently, the State of Washington has one of the largest artificial propagation systems in the world, with

a hatchery program that operates 24 complexes with 91 rearing facilities. Together they raise and release more than 201 million Pacific salmon, 8.5 million steelhead (salmon) trout and 22.6 million trout and warm-water fish (Maynard and Flagg 2001). Hatchery-bred fish help support the State's \$850 million per year sportfishing industry (*The Wave News Network* 2004).

A group called the Hatchery Review Group unveiled a new blueprint for the State of Washington's hatchery programs on April 23, 2004 (*The Wave News Network* 2004). The blueprint cost \$28 million to write and has more than 1,000 recommendations for improving the large salmon hatchery system. Examples include closing some hatcheries that are especially detrimental to wild stocks, and limiting the number of hatchery fish released so that they do not overrun wild stocks protected under the Endangered Species Act.

In addition, the state has 12 federal hatcheries and 35 tribal rearing facilities which produce another 50 million salmonids for release. In Oregon, the Department of Fish and Wildlife operates 34 hatcheries and 15 other rearing facilities, which release about 43 million Pacific salmon, 5.7 million steelhead (salmon) trout and 8.3 million trout. California has eight salmon and steelhead (salmon trout) hatcheries.

Depending on species and area, the salmon enhancement programs in the U.S. Pacific Northwest produce as much as 70 to 90% of salmon harvested in the commercial and recreational fisheries.

The potential for hatchery salmon to affect wild stocks went unrecognized for many years. Between the mid-1950s and early 1970s, scientists found increasing evidence that hatchery salmon was harming the remaining wild salmon runs. It seems clear now that hatcheries have had demographic, ecological and genetic impacts on wild salmon populations.

These effects include the reduction of genetic diversity within and between salmon populations, creation of mixed-population fisheries, altered behavior of fish, ecological imbalances due to the elimination of the nutritive contribution of carcasses of spawning salmon from streams, and the displacement of the remnants of wild runs (NRC 1996). As Hilborn (1992) notes:

Large-scale hatchery programs for salmonids in the Pacific Northwest have largely failed to provide the anticipated benefits; rather than benefiting the salmon populations, these programs may pose the greatest single threat to the long-term maintenance of salmonids... I argue that hatchery programs that attempt to add additional fish to existing healthy wild stocks are ill advised and highly dangerous.

As a result, academic, environmental and salmon advocate groups have proposed a redesign of the traditional objectives of hatchery management, which needs to shift away from producing more fish for harvest towards providing a means for the recovery and conservation of wild salmon populations (LLTK 2004; NRC 1996).

It is worth noting that there have been a few attempts at private salmon ranching, such as Ore Aqua Foods, a subsidiary of Weyerhaeuser and Anadromous Inc., a subsidiary of British Petroleum, both operating in Oregon during the late 1970s and 1980s. Private salmon ranching is based on the premise that smolts released from the private hatchery will return and will be captured by the "owner" of the fish. These have been unsuccessful primarily because ocean mortality is high and uncertain, and property rights related to salmon released to the ocean are poorly defined. In addition to these problems, salmon enhancement (public or private) may undermine the management of wild stocks through direct and indirect competition.

The 2005 *Atlas of Pacific Salmon* summarized the breadth and complexity of the issues related to salmon hatcheries in the U.S. Pacific Northwest and elsewhere.

The benefits of hatcheries are compelling: they may offset losses in abundance in naturally spawning stocks and reduce harvest pressure on wild populations; they help stabilize commercial harvest; and they serve as laboratories for the study and preservation of biodiversity. Hatcheries also provide a solid economic base for salmon-dependent communities, including native peoples.

Yet these benefits are counterbalanced with significant scientific uncertainty regarding freshwater and ocean carrying capacity, particularly within a trans-Pacific context . . . Interbreeding and brood stock transfer among rivers can challenge wild population viability and genetic integrity. Hatchery production can mask ecological problems at the heart of declines in wild populations. Artificial propagation can deprive rivers of marine-derived nutrients . . . essential to functioning freshwater ecosystems. Unfortunately, isolating impacts of hatchery fish on wild populations is extremely difficult, and so efforts to determine hatchery success or failure remain inconclusive.

Two legislative debates—whether to count hatchery fish under endangered species legislation . . . and whether to allow surplus hatchery fish to spawn in the wild—have fulminated in recent years, underscoring the fact that hatchery management is among the most controversial issues in fisheries today.

References

- Alaska State Senate, Special Committee on Domestic & International Commercial Fisheries. 1992a. Legislative Review of the Alaska Salmon Enhancement Program: Executive Summary. [Final Report, December]
- Atkinson, C.E. 1988. Fishery studies on the U.S. Pacific Coast, 1887-1931. *Marine Fisheries Review* 50(4):95-96.
- Augerot, Xanthippe (with Dana Nadel Foley). 2005. *Atlas of Pacific Salmon*. University of California Press, Berkeley, California.
- Bardach, J.E., J.H. Ryther, and W.O. McLarney. 1972. *Aquaculture – The Farming and Husbandry of Freshwater and Marine Organisms*. Wiley-Interscience, John Wiley & Sons, Inc., New York.
- Boyce, John; Herrmann, Mark; Bischak, Diane; Greenberg, Joshua. 1993. "The Alaska Salmon Enhancement Program: A Cost/Benefit Analysis." *Marine Resource Economics*, 8(4):293-312.
- Calabi, S. 1990. *Trout and salmon of the world*. The Wellfleet Press. Secaucus, New Jersey.
- Department of Fisheries and Oceans, Habitat and Enhancement Program. 2000a. Salmonid Enhancement Program web site: http://www-heb.pac.dfo-mpo.gc.ca/facilities/salmonid_e.htm.
- Department of Fisheries and Oceans. 2000b. *Final Report on Consultations for the Wild Salmon Policy Discussion Paper and the Salmonid Enhancement Program*. Report prepared for WSP-SEP Steering Committee, Fisheries and Oceans Canada by Dovetail Consulting Inc., Judith Cullington & Associates, and Devon Knight Events. November 2000. Available at http://www-comm.pac.dfo-mpo.gc.ca/pages/consultations/wsp-sep/wsp-sep_report_e.pdf
- Dodd, Question. 2003. "Canadian fish farmers tire of 'squeaky-clean' Alaskan image." *Northern Aquaculture*. 9(7).
- Environment and Natural Resources Institute, University of Alaska Anchorage. 2001. Evaluating Alaska's Ocean-Ranching Salmon Hatcheries: Biologic and Management Issues. Report prepared for Trout Unlimited, October. Available at: <http://www.tu.org/atf/cf/%7B0D18ECB7-7347-445B-A38E-65B282BBBD8A%7D/AKhatcheries.pdf>
- Farrington, Craig. 2003. *Alaska Salmon Enhancement Program: 2002 Annual Report. Regional Information Report 5J03-05*. Juneau, Alaska Department of Fish and Game. Available at the web site of the Alaska Department of Fish and Game: www.cf.adfg.state.ak.us/geninfo/enhance/enhance.htm.
- Farrington, Craig. 2004. *Alaska Salmon Enhancement Program: 2003 Annual Report. Regional Information Report 5J04-02*. Juneau, Alaska Department of Fish and Game. Available at the web site of the Alaska Department of Fish and Game: www.cf.adfg.state.ak.us/geninfo/enhance/enhance.htm.
- Fitzgerald, R., S. O. Stefansson, D. Garforth, and S. Irwin. 2002. Production II: From egg to market size: onrearing in freshwater and marine environments. Pages 65-104 in S.M. Stead and L. Laird, editors. *Handbook of Salmon Farming*. Springer-Praxis Series in Aquaculture and Fisheries. Chichester, UK.
- Gardiner, Terry. 1996. "Alaska Hatchery Policy Group Testimony for Norquest Seafoods," October 8. Testimony submitted to the Hatchery Policy Group, Alaska Department of Commerce and Economic Development.
- Hatchery Policy Group. 1997. *Report to the Salmon Industry Response Cabinet*. Available at the web site of the Alaska Department of Community and Economic Development, Office of Fisheries Development: www.dced.state.ak.us/cbd/seafood/seafoodreports.htm.
- Herrmann, Mark. 1993. "Using an International Econometric Model to Forecast Alaska Salmon Revenues." *Marine Resource Economics*, 8(3):249-272.
- Hilborn, R. 1992. Hatcheries and the future of salmon in the Northwest. *Fisheries* 17(1):5-8.
- Knapp, Gunnar. 1999. "Alaska Salmon Ranching: An Economic Review of the Alaska Salmon Hatchery Programme," in Bari Howell, Erlend Moksness and Terje Svåsand (eds.), *Stock Enhancement and Sea Ranching* (London, Blackwell Science, Fishing News Books).
- Long Live the Kings: Restoring Wild Salmon (LLTK). 2004. Puget Sound and Coastal Washington Hatchery Reform Project. Seattle, WA. <http://www.lltk.org/HRP.html>
- Loy, Wesley. 2003. "Pinks stripped of roe: Four million or more fish to be salvaged," *Anchorage Daily News*, August 19.
- Maynard, D.J. and T.A. Flagg. 2001. *Natures* rearing as a tool for increasing ranched salmon survival. *World Aquaculture* 32(2):56-58,69.

- McGee, Steven. 1995 (Updated 1998). *The Hatchery Program and Protection of Wild Salmon in Alaska: Policies and Regulations*. Alaska Department of Fish and Game web site: <http://www.cf.adfg.state.ak.us/geninfo/research/genetics/policy/hatchery.htm>.
- National Research Council (NRC). 1996. Upstream: salmon and society in the Pacific Northwest. Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, Board on Environmental Studies and Toxicology, Commission on Life Sciences. National Research Council, National Academy of Sciences, Washington, D.C. <http://eesc.orst.edu/salmon/human/hatcheries.html>
- Novak, T. 1998. A snapshot of salmon in Oregon – Hatcheries. Oregon State University Extension Service, Public Issues Education Initiative.
- Pacific Coast Salmon Fisheries (PCSF). 2004. History of conservation — Important events which have led to salmon conservation in British Columbia. Canada's Digital Collections. <http://collections.ic.gc.ca/pacificfisheries/habitat/histcon.html>
- Pacific Fisheries Resource Conservation Council (PFRCC). 2000. "Wild Salmon Policy" and the future of the Salmonid Enhancement Program: The Response of the Pacific Fisheries Resource Conservation Council. PFRCC Council Advisory. June 2000. http://www.fish.bc.ca/files/reports/WildSalmonPolicy_2000_0_Complete.pdf
- Scientific Certification Systems, Inc. 2000. *The Summary Report on Certification of Commercial Salmon Fisheries in Alaska*. http://www.msc.org/assets/docs/Alaska_Salmon/Salmon_Public_final_10_25_2000.doc
- Tkacz, Robert. 2003. "PWS goes for the Roe: Glut forces hatcheries to grind 'em up," *Alaska Fisherman's Journal*, October.
- Thorpe, J.E. 1980. *Salmon Ranching*. Academic Press, London, United Kingdom.
- Wahle, R.J. and R.E. Pearson. 1984. History of artificial propagation of coho salmon, *Oncorhynchus kisutch*, in the Mid-Columbia River system. *Marine Fisheries Review* 46(3):34-43.
- Washington Department of Fish and Wildlife (WDFW). 2004. Salmon Hatcheries. <http://wdfw.wa.gov/hat/overview.htm>
- Washington Salmon Growers Association. www.wfga.net.
- The Wave News Network*, 2004. "Fixing the world's largest salmon hatchery system," April 26.
- Wilén, James. 1993. "Technical Review of "A Benefit-Cost Analysis of the Alaska Salmon Enhancement Program." Prepared for Alaska Department of Fish and Game, June.
- Willoughby, S. 1999. *Manual of Salmonoid Farming*. Fishing News Books, Oxford, UK.