The Great Salmon Run: Competition Between Wild And Farmed Salmon

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TRAFFIC
NORTH AMERICA

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Front cover photos from the top, clockwise, are: salmon in display case, Gunnar Knapp; arial view of salmon farm, BC Salmon Farmers Association; salmon purse seinter, J. M. Olson, National Oceanic and Atmospheric Administration/Department of Commerce

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Executive Summary

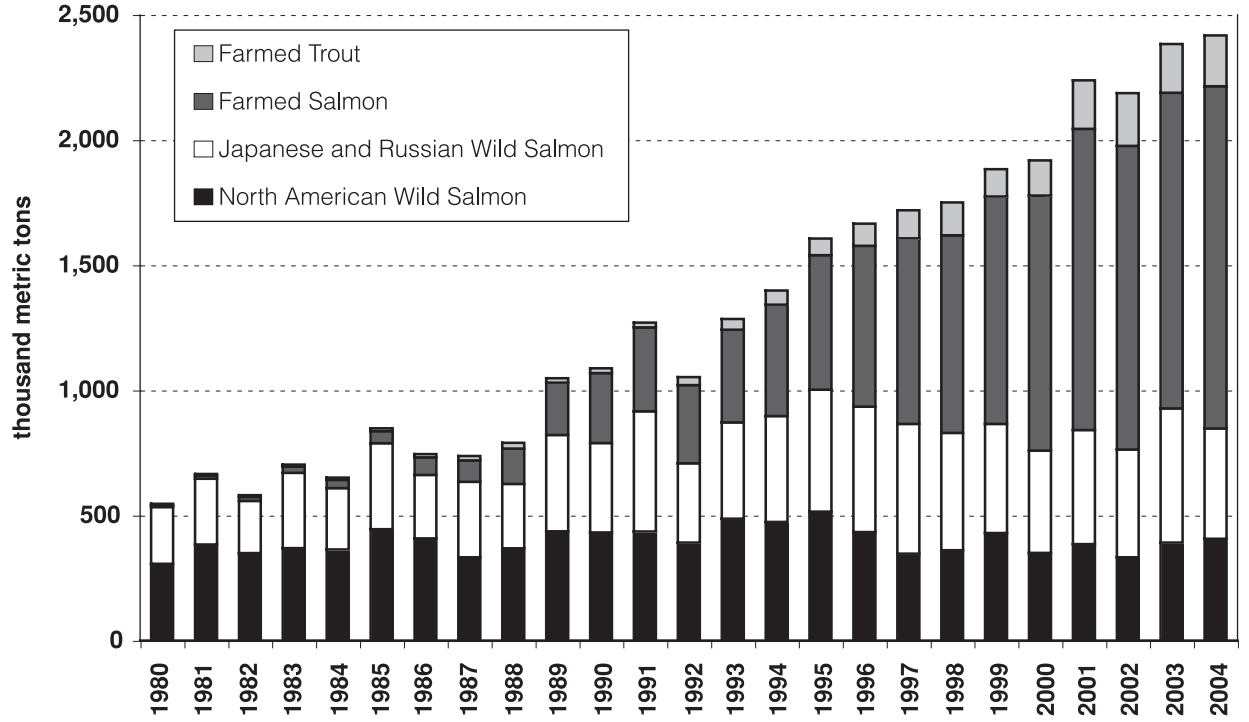
Background and Purpose

This report examines economic and policy issues related to wild and farmed salmon in North America. These issues have received a great deal of attention in recent years, reflecting the environmental, economic and cultural importance of salmon to Americans—and the fact that salmon issues span many important policy debates ranging from environmental protection to trade policy.

The salmon industry has experienced dramatic change over the past two decades. Two major trends gave rise to many of the issues discussed in this report. The first trend is the rapid and sustained growth in world farmed salmon and salmon trout production, from two percent of world supply in 1980 to 65 percent of world supply in 2004 (Figure 1). This development has fundamentally transformed world salmon markets—not only because of the dramatic growth in total supply, but also because of changes in the kinds of salmon products which are available, the timing of production, market quality standards and organization of the industry.

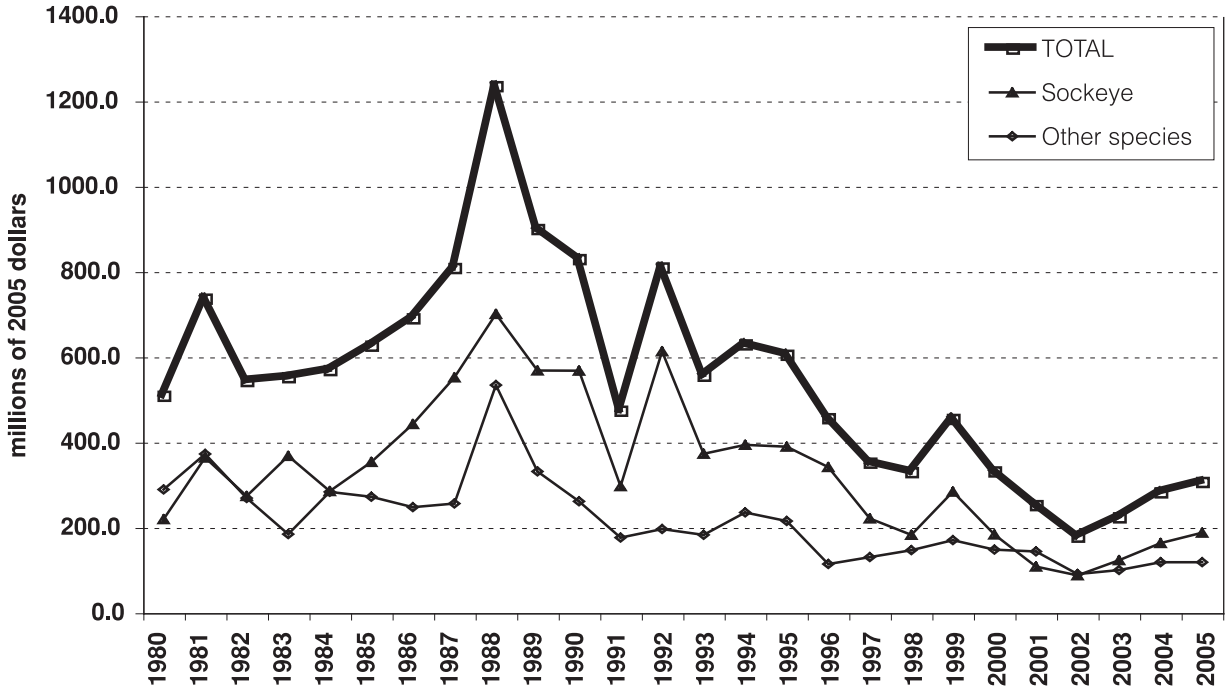
The second trend is a steep decline in the value of North American wild fisheries, as seen in the decline in the value of annual Alaska salmon catches from more than $800 million in the late 1980s to less than $300 million for the period 2000-04 expressed in 2005 dollars (Figure 2). Most of this decline in value was due to a decline in prices (rather than catches), and much of the decline in prices was due to competition from farmed salmon.

Figure 1 **World Salmon and Trout Supply 1980-2004**



Source: All data are FAO Fishstat+ data except that data (used to calculate North American wild salmon catches) for Alaska are CFEC Alaska Salmon Summary Data 1980-2005 and data for the Pacific Northwest are NMFS catch data. "Farmed trout" includes only farmed rainbow trout raised in salt water.

Figure 2 **Real Ex-Vessel Value of Alaska Salmon Catches, 1980-2005**



Source: CFEC Alaska Salmon Summary Data 1980-2005. Adjusted for inflation based on Anchorage CPI.

The growth of farmed salmon and the decline in the value of wild salmon has given rise to two broad sets of questions:

- How has salmon farming affected wild salmon resources and the wild salmon industry?
- What should be done to protect wild salmon resources and strengthen the wild salmon industry?

Inherent within these questions are numerous, wide-ranging and complex issues. These issues are often oversimplified and misunderstood, leading to ill-conceived policy recommendations. The primary purpose of this report is to inform people who care about these issues—particularly policymakers, the environmental community, and the fishing industry—about the wild and farmed salmon industries and the economic relationships between them, to provide a sound basis for achieving environmental and economic goals.

Readers seeking simple answers about salmon issues will be disappointed. Nothing is simple about salmon, salmon fisheries or salmon markets. An understanding of salmon biology, fisheries management, hatcheries and aquaculture is fundamental to understanding relationships between wild and farmed salmon. An understanding of salmon products, markets, consumers and the distribution chain is fundamental to understanding how and why prices have changed.

This report consists of twenty chapters. The table below summarizes major questions addressed by each

The remainder of this executive summary reviews selected major conclusions of the report. Readers are strongly encouraged to refer to the full report for the detailed analyses on which these conclusions are based.

Table 1 **Organization of this Report**

Chapter		Major questions
I	Introduction	An introduction to the purpose and organization of the report.
II	North American Wild Salmon Resources	The five major wild Pacific salmon species differ significantly in characteristics which affect their suitability for different products and markets. Wild Pacific salmon are harvested in three major regions: Alaska, British Columbia and the U.S. Pacific Northwest. What are important differences between species? What is the status of wild salmon resources in different regions?
III	North American Wild Salmon Fisheries	There are important regional differences in the relative scale and status of salmon runs; the environmental conditions for salmon habitat; the mix of species harvested; the mix of commercial, sport and aboriginal uses; the regulatory framework for salmon fishing; and economic, social and political conditions. What are these differences?
IV	The Role of Hatcheries in North American Wild Salmon Production	What role do hatcheries play in salmon fisheries management, and to what extent do commercial salmon fisheries rely on hatchery production? What issues are raised by salmon hatcheries?
V	The World Salmon Farming Industry	What is the history of salmon farming, what is its status, and how are current events and market conditions shaping the future of farmed salmon production worldwide?
VI	Overview of World Salmon Markets	Major world salmon markets include the Japanese, European and U.S. fresh and frozen markets and canned salmon markets. How do these markets compare in relative size, sources of salmon supply and price trends?
VII	Products and Markets for North American Wild Salmon	Major wild salmon products include canned salmon, frozen salmon, fresh salmon and salmon roe. What is the relative importance of domestic and foreign markets for these products? How do products and markets vary by species?
VIII	Overview of U.S. Salmon Consumption	How has U.S. consumption of wild and farmed salmon, as well as domestic and imported salmon, been changing over time for different species and products?
IX	North American Salmon Trade	What are trends in U.S. exports and imports of wild and farmed salmon? What features of farmed salmon make it attractive to buyers in the United States?
X	The U.S. Salmon Distribution System	How do salmon products get from fisherman to consumer? How and why do prices change as salmon products move through the distribution system? How is the distribution system changing?
XI	Overview of U.S. Salmon Consumers	What is known about salmon consumers in the United States? What do market surveys completed in the past 15 years indicate about what kinds of consumers eat salmon and how consumption and attitudes about wild and farmed salmon have evolved in recent years?
XII	Overview of North American Salmon Marketing	What are the major challenges to marketing wild salmon? What efforts have been made by the wild salmon industry to market wild salmon, and how is wild salmon marketing changing? How is farmed salmon marketed?
XIII	Effects of Farmed Salmon on Prices of Wild Salmon	How has the increased supply of farmed salmon affected salmon markets, salmon prices and the value of wild salmon catches?
XIV	Economic and Social Effects of Changes in Wild Salmon Markets	How have these changes in markets, prices and values affected the people who depend upon wild salmon, including fishermen and fishing communities, particularly in Alaska?

Table I **Organization of this Report** *continued*

Chapter		Major questions
XV	Overview of Salmon Trade Policy Issues	Could trade policies be used to raise prices for wild salmon? What has been theU.S. experience with the use of trade policies to protect the U.S. salmon industry?
XVI	Analysis of Marine Stewardship Council (MSC) Certification of Alaska Salmon	The Marine Stewardship Council (MSC) has certified Alaska's salmon fisheries as sustainable. What have been the effects of this certification? Does MSC certification translate into higher prices and stronger competitiveness with farmed salmon?
XVII	Seafood Labeling Programs and Potential Implications for North American Salmon	What is the potential for other labeling program to benefit markets for wild salmon, including country-of-origin labeling, farmed versus wild labeling, and potential organic labeling of farmed salmon. To what extent are these kinds of labeling programs occurring?
XVIII	The Future of Salmon Aquaculture in North America	How is North American salmon farming and consumption likely to change in the future? How are product attributes of farmed and wild salmon likely to affect demand for major buyers?
XIX	Effects of Salmon Farming On North American Wild Salmon Resources	Much of the public debate about farmed and wild salmon has been about potential effects of salmon farming on wild salmon populations. What are potential mechanisms and the potential scale of these effects?
XX	Outlook for the Future and Recommendations	Summary of the report, outlook for the future and recommendations

North American Wild Salmon Resources

Wild salmon are very important to many different people in North America. For well over a century, the commercial wild salmon industry has provided a living—and a way of life—to fishermen, processors, and coastal communities from California to Alaska. Sport fishermen are passionate about sport fishing for salmon, and sport fishing has become a big business for many coastal communities. Native Americans have relied upon salmon for thousands of years, and continue to actively participate in subsistence and commercial fisheries. The general public—including those who do not fish for salmon—are stirred by the annual return of the salmon and derive value simply from the fact that these salmon continue to be found in our rivers. All of these stakeholders wish for sustainable wild salmon fisheries.

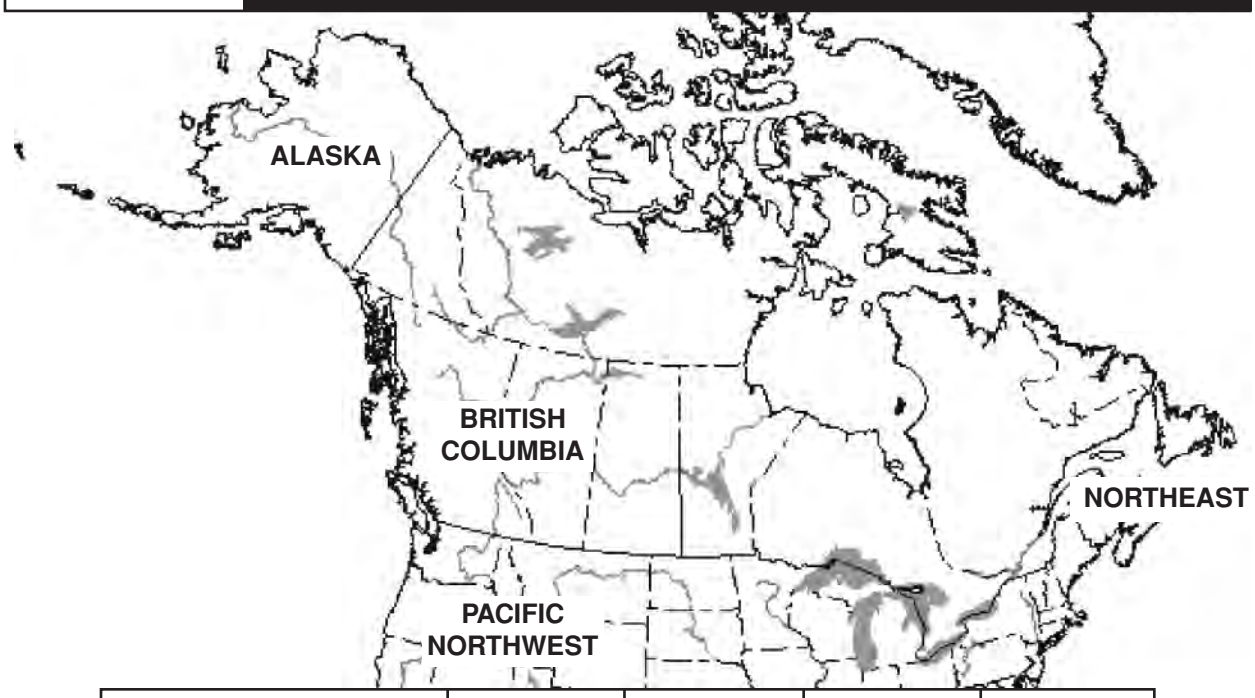
Pacific and Atlantic salmon are members of a large family of fish known as *salmonidae*. Salmon are anadromous: they spawn in fresh water and the young migrate to the sea where they mature. Most salmon return to the stream of their birth, although some may stray to other streams.

Five species of Pacific salmon (genus *Onchorhynchus*) are fished commercially: Chinook salmon *Onchorhynchus tshawytscha*; sockeye salmon *Onchorhynchus nerka*; coho salmon *Onchorhynchus kisutch*; pink salmon *Onchorhynchus gorbuscha*; and chum salmon *Onchorhynchus keta*. Atlantic salmon *Salmo salar* spawn in limited numbers in New England and the Canadian maritime provinces; however, there are currently no North American commercial fisheries for Atlantic salmon.

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. Imperfect data are available on the status of wild salmon resources. While what matters for the health of the resource is the number of fish returning and spawning, 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 and commercial fishing regulations.

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; very little information is available 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.

Figure 3 **Salmon Producing Regions of North America**



	Alaska	British Columbia	Pacific Northwest	Northeast
Wild species	Pacific	Pacific	Pacific	Atlantic
Wild stocks condition	Strong	Mixed	Weak	Very Weak
Average commercial wild catches, 1996-2001 (000 mt)	346	29	10	0
Farmed production, 2001 (000 mt)	0	68	17	67

Sources: Alaska wild catches: CFEC Alaska Salmon Summary Data 1980-2005; BC wild catches: FAO Fishstat+ data; Pacific Northwest wild catches: NMFS catch data; Aquaculture Statistics for BC farmed production (67.7 thousand mt) and Eastern Canada farmed production (37.6 thousand mt): Statistics Canada Aquacuture Statistics. Maine farmed salmon production (29.1 thousand mt) from Maine DMR Farmed Salmon Data. Pacific Northwest farmed salmon production (16.7 thousand mt) from Washington DFW Farmed Salmon Data.

In studying the North American wild salmon industry, it is useful to distinguish between four salmon producing regions: Alaska, British Columbia, the U.S. Pacific Northwest, and Maine and maritime Canada. There are important differences between these regions in the condition of wild salmon resources, the scale of catches, the economic importance of the industry and the scale of salmon farming (Figure 3).

The conventional wisdom is that Alaskan salmon stocks are abundant and healthy, and that strong salmon returns since the 1980s reflect a commitment to protect salmon habitat and conservative resource management. Unlike more settled parts of North America, over vast areas of Alaska, there has been relatively little human disturbance to the environment—no roads, dams, farming, logging or mining. The absence of disturbance to the freshwater environment has been an important factor in the relative health of Alaskan salmon resources.

Because of the relative abundance of the resource, Alaska dominates the North American commercial wild salmon industry. For that reason, much of the emphasis in this body of this report is on Alaskan salmon.

In British Columbia, after record catches in many commercial salmon fisheries during the mid-1980s, 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 coast of the province 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 stocks are still

considered to be depressed. In general, most British Columbia chinook, sockeye and pink salmon stocks are considered "healthy," while the status of coho and chum salmon stocks is considered "mixed."

The status of individual salmon stocks in the U.S. Pacific Northwest region varies widely. Efforts to rebuild stocks face daunting technical, economic and political challenges. How to rebuild 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, Pacific Northwest salmon catches are much smaller than those of Alaska, and of relatively limited and local economic significance.

In the Northeast Atlantic region, wild Atlantic salmon were historically found in rivers in New England, Quebec, the Maritime Provinces and Newfoundland. In the U.S. Atlantic salmon were once native to nearly every major coastal river north of the Hudson River. Currently, 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.

In eastern Canada, wild Atlantic salmon populations have declined by more than 75 percent since the 1970s, when 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 considered to be in serious trouble.

North American Wild Salmon Fisheries

North American wild salmon fisheries may be generally divided into three broad types of fisheries: commercial, sport, and aboriginal. All three types of fisheries are important, but their relative importance varies widely between different regions.

In this report, our focus is entirely on commercial wild salmon fisheries. In 1999, commercial fisheries accounted for about 98 percent of Alaska catches, 89 percent of British Columbia catches, and 96 percent of Pacific Northwest catches. While commercial fisheries account for almost all sockeye, pink and chum salmon catches, the share of commercial fisheries is lower for chinook and coho salmon, for which sport fisheries account for about one-fifth of total catches.

Although commercial fisheries dominate wild salmon catches, sport and subsistence salmon fisheries are also very important in all regions. Salmon sport fishing is prized by anglers from Atlantic Canada to the Pacific Northwest, British Columbia and Alaska—and providing guiding, lodging and other services to sport fishermen is a major economic activity that in some areas rivals or exceeds commercial fisheries in value and economic impact. "Subsistence" catches—primarily aboriginal—are very important for food and cultural traditions in some regions.

Management of North American Commercial Salmon Fisheries

Similarities and differences exist in the management of commercial wild salmon fisheries in Alaska, British Columbia and the U.S. Pacific Northwest states of Washington, Oregon and California. In part, these reflect variations in the relative scale and status of salmon runs and the mix of commercial, sport and aboriginal uses, as well as differences in regulatory institutions resulting from different political, legal, economic and social conditions.

Alaska's commercial salmon fisheries are managed under a "limited entry" program, which was established in the 1970s to limit growth in the number of people fishing in the salmon industry. Alaska has twenty-six different salmon fisheries, defined by fishing area and the type of fishing gear which may be used. Major gear types include purse seine, drift gillnet, set gillnet, and power troll. For each fishery, there are a fixed number of "limited entry permits." Only holders of these permits (and their crew) are allowed to operate fishing gear. There are also numerous restrictions on boats and gear. Individuals may hold more than one salmon permit, but they may participate in only one salmon fishery per season.

Alaska has "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.

There is wide variation between Alaska salmon fisheries in volume harvested, earnings, numbers of permits and average permit prices. While prices and catches were high, most Alaska fishermen and fishery managers were not concerned about overcapacity or inefficiency in these salmon fisheries. However after the value of catches began to decline in the 1990s, many fishermen experienced an economic squeeze as their fishing revenues were no longer sufficient to cover their costs. For many permit holders, the loss in fishing profits was aggravated by a sharp decline in the

Photograph by Bart Eaton

Crowding in Alaska's Bristol Bay drift gillnet salmon fishery. There are more boats than needed to catch the available fish, adding to costs and reducing profitability.

asset value of their limited entry permits. In some fisheries a significant share of permits are no longer being fished, as permit holders have concluded that they cannot make enough money fishing to cover their costs. In many fisheries the number of boats remains well above the levels needed to catch the available fish. The relative decline has not been the same for all fisheries.

As the economic difficulties of the Alaska wild salmon industry increase, there is growing awareness of how the management system adds to costs and lowers quality, thereby adding to the difficulties Alaska salmon faces in competing with farmed salmon. At the same time, there is strong resistance to changes in management, because of the economic and social disruption that such changes might mean.

In British Columbia, the Canadian federal government has sole responsibility for management of salmon fisheries. The fisheries are managed by the Department of Fisheries and Oceans (DFO). DFO implemented limited entry licensing for British Columbia salmon fisheries in 1969. Currently, licenses are issued for three gear groups: seine, gillnet and troll vessel.

In British Columbia, consecutive poor salmon seasons in 1995 and 1996, during which incomes and profits fell to record lows, as well as ongoing concerns for conservation of salmon, led the federal government to introduce a Pacific Salmon Revitalization Strategy in 1996. The plan implemented area and gear licensing for the salmon fleet which limited license holders to fishing with a single gear type in a specified area. It also allowed "stacking" of more than one license on a single vessel. British Columbia further provided for the voluntary purchase or retirement of commercial salmon licenses. A $280 million buyback program resulted in a decline in the number of commercial salmon licenses from approximately 4,400 to 2,200 between 1995 and 2000.

In the U.S. Pacific Northwest, non-treaty fisheries are also managed under limited entry systems. Catches are restricted by restrictions on fishing times, areas and gear types. Permit numbers have been significantly reduced by buyback programs. Commercial salmon fisheries in the region include both in-river and ocean fisheries using troll, gillnet, seine and several other kinds of gear. Management of these fisheries is greatly complicated by widely varying conditions of wild salmon stocks, the fact that many commercial fisheries are mixed stock fisheries (catching fish returning to different river systems), the presence of interception fisheries (in which fish are caught by a series of different groups as they return from the ocean to spawning grounds) and the importance of salmon to many different user groups. There are also a large number of institutions involved in fishery management and a diversity of commercial fishing user groups. For example, sport catches play a significant role of in total salmon catches, and hatchery fish play a major role in commercial and sport catches.

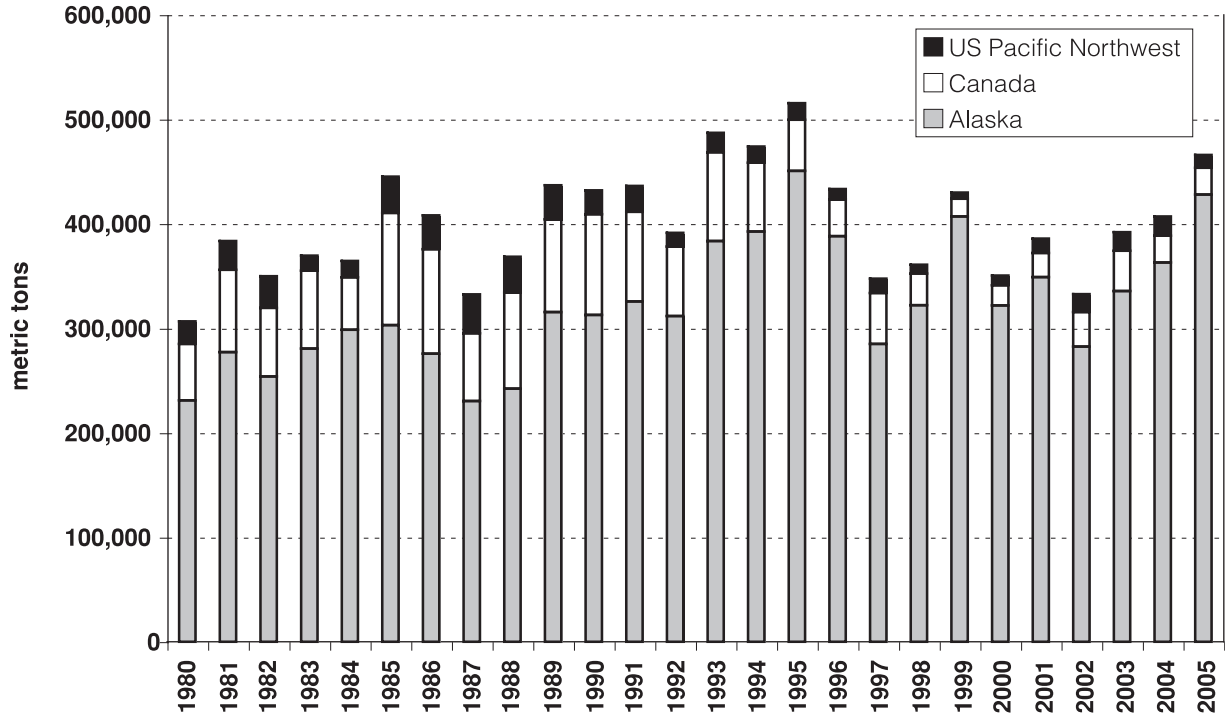
North American Commercial Salmon Catches

Hundreds of millions of Pacific salmon are caught each year in commercial salmon fisheries. Alaskan salmon catches dwarf those of other regions, and increased dramatically during the 1980s and early 1990s to record levels. Alaska fishery managers and politicians generally attribute the increase to conservative state management of salmon resources, the end of high-seas catches and production from the Alaska salmon hatchery program.

During the five-year period 1996-2000, combined Alaskan catches of chinook, sockeye, coho, pink, and chum salmon averaged more than 350,000 mt per year. British Columbia catches of the same species during this period totalled slightly less than 30,000 mt, and U.S. Pacific Northwest catches were less than 10,000 mt. Alaska accounted for 90 percent of the total harvest volume; British Columbia accounted for 8 percent, and the Pacific Northwest accounted for only 2 percent (Figure 4).

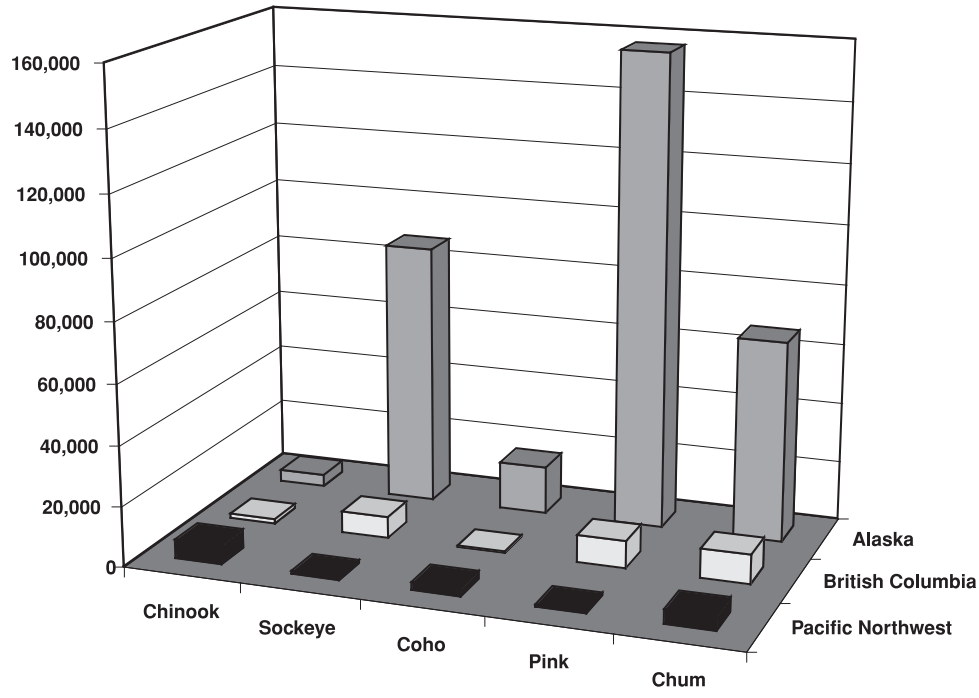
During 2000-2005, pink salmon accounted for the largest share of Alaska catch volume (47 percent), followed by sockeye (26 percent), chum (20 percent), coho (5 percent) and chinook (1 percent) (Figure 5). In British Columbia, chum salmon accounted for the largest share

Figure 4 **North American Commercial Salmon Catches, by Region, 1980-2005**



Source: Alaska: CFEC Alaska Salmon Summary Data 1980-2005; Canada: 1980-2004: FAO FISHSTAT+ data; 2005: DFO Salmon Catch Volume Data 1996-2005. Pacific Northwest: 1980-2004: NMFS Catch Data; 2005: PACFIN salmon data.

Figure 5 **Average Commercial Salmon Catches, 1996-2000, by Species and Region (metric tons)**



Source: Alaska: CFEC Alaska Salmon Summary Data 1980-2005; Canada: FAO FISHSTAT+ data; Pacific Northwest: NMFS Catch Data.

(35 percent), followed by pink (33 percent), and sockeye (26 percent). In the U.S. Pacific Northwest, chinook salmon accounted for the largest share (41 percent), followed by chum salmon (31 percent), and coho (17 percent). Thus, while Alaska accounted for 94 percent of pink salmon catches it accounted for only 34 percent of chinook salmon catches.

Alaska catches set all-time records during the mid 1990s and remain strong for chinook, coho, pink, and chum salmon. Alaska sockeye salmon catches fell by more than half between 1995 and 2002, but have since rebounded significantly. The decline in catches of sockeye salmon—which typically command the second highest price per pound and constitute more than half of the ex-vessel value of Alaska salmon catches—has been a significant factor contributing to the economic difficulties of Alaska salmon fishermen in recent years. It is uncertain what has caused this decline in sockeye, but ocean conditions, stream conditions, and other environmental changes are the most likely causes.

Importance of Sockeye Salmon in Commercial Catches

As discussed above, between 1988 and 2002 there was a steep decline in the real ex-vessel value of Alaska commercial salmon catches ("ex-vessel value" is the value paid to fishermen). British Columbia salmon fishermen have experienced an even more dramatic decline. More than half of this decline was in the value of sockeye salmon catches. The decline in value of sockeye catches resulted from a decline in both sockeye prices and sockeye catches. The modest rebound in value since 2002 has also resulted primarily from an increase in sockeye catches and prices.

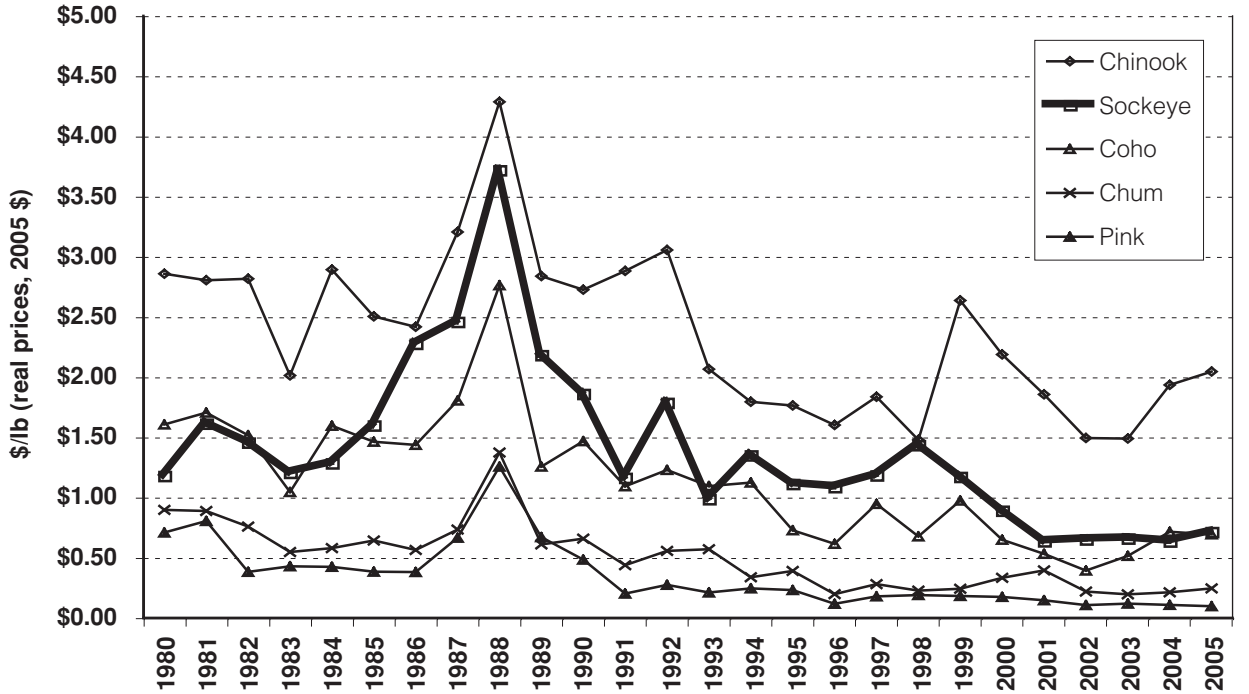
In most years, sockeye salmon accounts for well over half of the value of Alaska salmon catches—the result of a combination of high catches and high prices. For this reason, Alaska fishermen sometimes refer to sockeye salmon as "money fish."

This role of sockeye salmon is important to emphasize, because until recently almost all Alaska sockeye salmon was either frozen and sold in Japan or canned. Only a very small share was sold in the U.S. fresh and frozen market. Thus much of the decline in sockeye catch value (and the total Alaska catch value) had very little to do with competition between farmed and wild salmon in the U.S. fresh and frozen salmon market—but resulted rather from changes in other markets.

Wild Alaska Salmon Prices

Different species command dramatically different prices, and the relative ranking of different species tends to stay the same in most (but not all) years. Chinook salmon command the highest ex-vessel prices—well over $1.00 per pound. Ex-vessel prices for sockeye and coho salmon are in a middle range—generally between $0.50 and $1.00 per pound in recent years. Prices for chum and pink salmon are significantly lower, generally less

Figure 6 **Average Real Ex-Vessel Prices for Alaska Salmon, 1980-2005 (adjusted for inflation)**



Source: CFEC Alaska Salmon Summary Data 1980-2005. Adjusted for inflation based on Anchorage CPI.

than $0.30 per pound for chum and less than $0.15 per pound for pink salmon in recent years.

After rising during the 1980s, there was a significant downward trend in prices for all species from 1988 to 2002. Since 2002, inflation-adjusted price trends have differed between species. Real prices for chinook and coho salmon, in 2005 dollars have risen significantly, prices for sockeye salmon have risen slightly, and prices for pink and chum salmon have stayed about the same (Figure 6).

The causes of the decline in prices are complex, and they vary between species. A different mix of products is produced from each species, which sell into different markets. However, for most species the single most important factor contributing to the decline in prices has been growing competition from farmed salmon.

Contribution of Hatcheries to Wild Salmon Catches

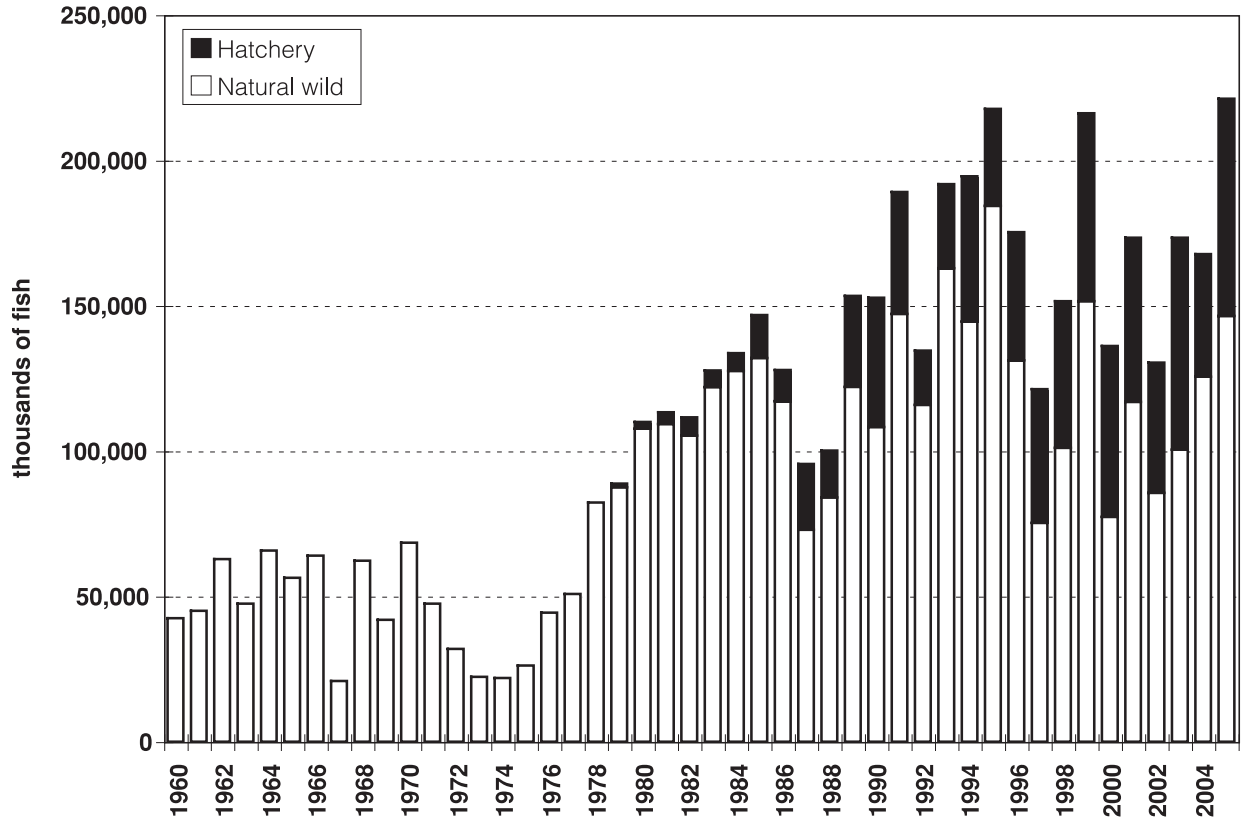
A large share of salmon returning to North American streams is released from hatcheries. Sometimes referred to as "ranched salmon," hatchery fish contribute significantly to North American wild salmon catches (Figure 7). More than two billion Pacific salmon were released in 2000 by North American hatcheries. Alaska accounted for 69 percent of total releases, while Canada and the Pacific Northwest each accounted for about 16 percent.

Hatcheries recreate the early portion of the life cycle of the species in a protected environment and consist of both a freshwater and a marine phase. The freshwater phase encompasses the spawning cycle, egg production, hatching and first-feeding stages.

Alaska's salmon hatcheries, originally developed with substantial state funding, are now operated primarily by private non-profit associations funded in part by taxes on fishermen and in part by special "cost-recovery" fisheries conducted by the 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.

The relative importance of hatcheries varies between different areas of Alaska. In 2002, Southeast Alaska and Prince William Sound accounted for about 80

Figure 7 **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

percent of hatchery catches. 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.

Although hatcheries have clearly increased Alaska salmon catches, they have not stabilized catches. Salmon catch by region and in the state as a whole still vary greatly from year to year, because hatchery fish are subject to the same ocean conditions as wild salmon.

A number of issues have arisen with regard to Alaska's salmon hatchery program. 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. As prices declined during the 1990s, hatcheries' operating costs came to represent an increasing share of the value of hatchery fish, raising further questions about the net economic benefits and economic viability of hatcheries.

Some critics 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 likelihood for over-harvests of natural wild fish runs. Finally, 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.

In British Columbia, the Canadian Department of Fisheries and Oceans launched a Salmonid Enhancement Program (SEP) in 1977. 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 province's sport and commercial salmon catch originates from SEP projects, and about a dozen terminal fisheries at hatchery release sites are dependent on enhanced stocks (DFO 2000).

There is, however, significant doubt about whether the SEP is succeeding. A 2000 review concluded that it was difficult to say whether the SEP had produced any net gain of salmon, and that there was evidence to suggest that it had contributed to a net loss of wild salmon abundance, partly because of competition of juvenile hatchery fish with wild juvenile fish, and partly because of unsustainably high harvest rates on co-migrating wild salmon (Pacific Fisheries Research Council 2000).

In the U.S. Pacific Northwest, depending on species and area, salmon enhancement programs produce as much as 70 to 90 percent of salmon harvested in commercial and recreational fisheries. Between the mid-1950s and early 1970s, scientists found increasing evidence that hatchery salmon were harming remaining wild salmon runs. It seems clear now that hatcheries have had demographic, ecological and genetic impacts on wild salmon populations, including 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 a result, academic, environmental and salmon advocate groups have proposed a redesign of the traditional objectives of hatchery management, from producing more fish for harvest towards providing a means for the recovery and conservation of wild salmon populations (LLTK 2004; NRC 1996).

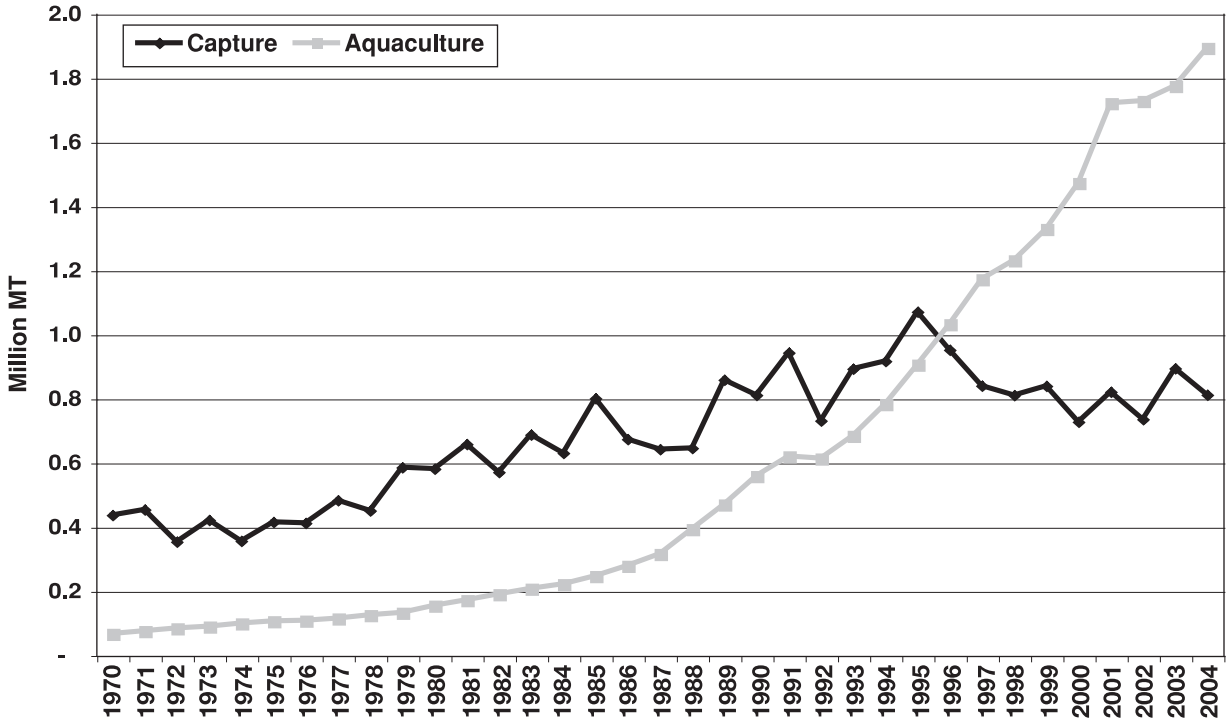
Overall, hatcheries add another dimension of complexity and ambiguity to the environmental, economic and social issues related to wild and farmed salmon. Once thought of as a way to restore and enhance natural wild salmon runs, hatchery salmon are now recognized as potentially harmful to natural wild salmon runs because of genetic interactions and competition for food and habitat in freshwater and marine environments. Particularly in the U.S. Pacific Northwest, there is an active debate among scientists, commercial fishermen and the public as to the appropriate role and scale of salmon hatcheries.

Farmed Salmon Production

Commercial salmon farming began in the 1970s. During the 1980s and 1990s, commercial salmon farming became well established in many temperate countries around the world. Global farmed salmon production exceeded the world's total commercial harvest of wild and ranched coho and chinook salmon by the mid-1980s, and it exceeded all commercial harvests of wild salmon by 1996 (Figure 8).

Of the several salmonid species cultured for commercial purposes worldwide, Atlantic salmon is by far the most important. Its potential for farming is excellent since it is relatively easy to handle, grows well under culture conditions, has a relatively high

Figure 8 **World Production of Salmon and Trout: Capture Fisheries vs. Aquaculture**



Source: FAO (2006)

commercial value and adapts well to farming conditions outside its native range. Of the Pacific salmon that are caught in North America, only chinook, coho and steelhead (salmon trout) are farmed in substantial quantities.

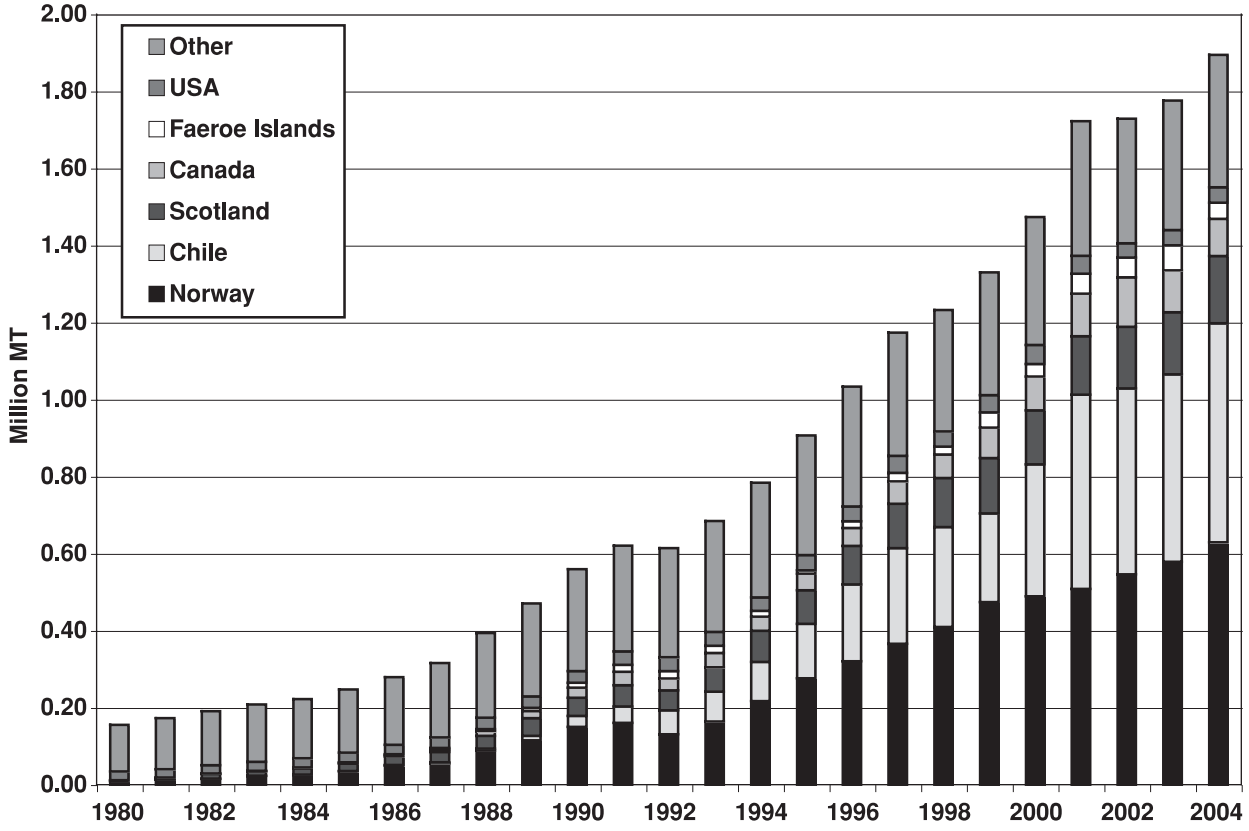
About three-fourths of the fresh and frozen salmon consumed in the United States is now farmed. As production costs of farming salmon have declined, farmed salmon production has continued to grow. Prices for both wild and farmed salmon have trended downwards—creating problems for both wild and farmed salmon producers.

It should be noted, however, that while most U.S. salmon consumption derives from farmed product, the U.S. salmon farming industry, mostly in Washington and Maine, in 2002 accounted for less than 1 percent of world farmed salmon production, and it is likely to continue to decline in market share. Alaska has a permanent moratorium on salmon farming. Competitiveness of U.S. farmed salmon producers has been seriously eroded in recent years by the escalating cost of regulatory compliance covering almost all aspects of production, including disease control, feed additives, effluent discharges, marine mammals, navigation and control of predatory birds and endangered species.

Canadian salmon farming takes place primarily in British Columbia and New Brunswick. In British Columbia, growth in recent years has been hampered by conflicts with commercial and recreational salmon fisheries as well as First Nations and environmental groups. The industry is heavily regulated. It has been claimed that farm installations may spread diseases and escaped Atlantic salmon may negatively affect wild Pacific salmon populations. In New Brunswick, although the industry benefits from proximity to large eastern U.S. markets, expansion is limited by a shortage of suitable sites, low ocean temperatures in the winter and growing controversies over disease control and effects of farming on native wild Atlantic salmon. Despite these constraints, Canadian farmed salmon production increased steadily until 2002, but has since declined.

Outside of North America, commercial salmon farming takes place in nations as diverse as Norway, the Faroe Islands (Denmark), Japan, Ireland, Scotland (the United Kingdom) and Chile, with multinational corporations often controlling operations in several nations. Norway and Chile have become the dominant farmed salmon-producing countries, in part because the regulatory environment has generally been supportive. Norway became an important producer of farmed salmon in 1984 (Figure 9).

Figure 9 **World Aquaculture Production of Salmon and Trout**



Source: FAO (2006)

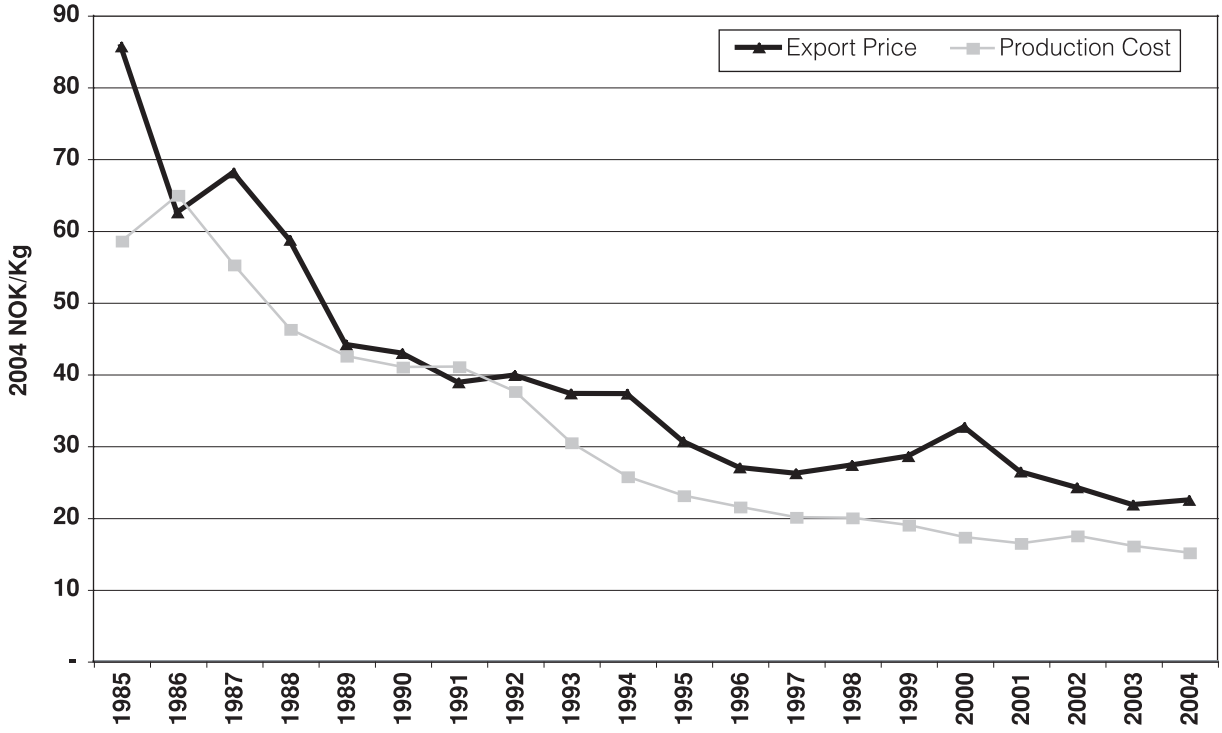
Chile became the second largest producer of salmon in the world in 1992, and now produces at a level commensurate with Norway. The average growth rate of the industry for the period 1984-2002 was 52 percent per year. The presence of numerous unpolluted freshwater sources and the fact that most lakes do not freeze in winter provide favorable conditions for smolt production throughout the year. In addition, Chile's salmon farming industry has benefited from easy access to fishmeal for feed, low-cost skilled labor, minimum interference from commercial and recreational fishermen, a favorable regulatory climate and less pressure from environmental groups than elsewhere (Hicks 1995).

Many factors have contributed to the success of salmon aquaculture operations worldwide. These include relatively inexpensive and easily replicated technology, widely available sites with ideal environmental and topographical conditions, favorable culture traits of Atlantic salmon, increases in production efficiency, and growing market demand for salmon. The growth of salmon aquaculture was motivated by several factors. On the demand side, salmon farmers realized an opportunity to provide a consistent (size, availability, high quality) fresh salmon at a relatively high price year-round. They recognized significant market growth potential and that wild salmon fisheries could not adequately supply the market with uniform fresh salmon of consistently high quality year round. As a result, farmed salmon created a market in the United States and Europe that wild salmon could not supply. As a fresh product, farmed salmon received a price premium compared to most frozen wild salmon.

The growth in farmed salmon was also stimulated by production and institutional factors. Over the past twenty-five years, broodstock quality, feed quality, disease management techniques and processing have all improved. Through consolidation, economies of scale have occurred. These factors resulted in a steady decline in production costs, providing the means for increasing production even with a fall in salmon prices. Figure 10 shows inflation-adjusted production costs contrasted with export prices in Norway, in 2004 Norwegian kroner, with a distinct downward trend.

The largest cost component of production costs is feed. In the 1980s, feed conversion ratios (FCR) in Norway were around 3 kilograms of feed per kilogram of salmon. In 1999, the average feed conversion ratio was

Figure 10 **Export Price and Production Cost of Norwegian Atlantic Salmon (1985-2004)**



Source: Norwegian Directorate of Fisheries 2006 (provided by Frank Asche, University of Stavanger, Norway).

1.19 kilograms of feed per kilogram of salmon (Guttormsen 2002). The reduction in production costs and FCR was made possible through consolidation and vertical integration of the industry, better broodstock, technology and improvements in nutrition, disease management and farm production systems (Asche et al. 2003). Undoubtedly, the many efforts conducted by the industry since 1989 to expand and broaden the market have been instrumental in dealing with the downward pressure on prices.

Critiques of Salmon Farming

Some scientists and NGOs have expressed concerns about environmental impacts of salmon farming and the safety of farmed salmon, which have received significant press coverage. These issues are the subject of significant scientific debate with many scientists disputing the critiques which have been raised. This report addresses these issues only in the context of the economic implications of this ongoing debate.

Salmon is a carnivore and requires a diet with a high protein content to promote and sustain growth rates throughout the entire life cycle. The dependence of salmon farming on the availability of high-quality proteins such as fishmeal and fish oil has raised some concern among environmental groups about potentially negative effects on wild fish stocks. The concern over the sustainability of the stocks of fish from which fishmeal are derived is partly based on a concern that as aquaculture production grows, there is increased pressure on these stocks with several economic, environmental and social implications.

Although the share of fishmeal going to aquaculture is increasing (Delgado et al. 2003), the majority of the fishmeal produced worldwide goes to developing nations and is used as feed for livestock, primarily poultry and pigs. In 1986 only 8 percent of fishmeal produced worldwide was going to aquaculture production (Wijkstrom and New 1989). By 1995, 25 percent was going to aquaculture (Tacon 1998), and in 2002 it was up to an estimated 34 percent (Barlow 2002).

As demand for fishmeal has increased, the cost of fishmeal is generally increasing. The resulting economic incentive has been to undertake a significant amount of research to reduce the dependence of salmon feeds on fishmeal and fish oil. Improved feed conversion ratios and reduced amount of fishmeal in salmon diets indicate success in these research efforts, as do the reduction in farmed salmon production costs (Guttormsen, 2002; Asche, Bjørndal, and Sissener, 2003).

A recent report published in Science claims that farmed salmon contain higher levels of PCBs than their wild counterparts, that 8 ounces of farmed salmon should not be consumed more than once per month, and the

source of the PCB contamination is the fish feed (Hites et al. 2004). The study also indicated that farmed salmon from northern Europe had higher concentrations of contamination than farmed salmon from South America. The study was based on salmon taken from the water in 2001 and has not been replicated since. This study was highly controversial and has been challenged by the medical community and food scientists who have argued that the benefits of eating fish rich in fatty acids are more clearly proven than the risk of PCB exposure (SOTA 2004; Santerre 2004; Willett 2005).

There are two critical issues in this controversy: a) public health, and b) impact on the farmed and wild salmon industries. Claims that farmed salmon pose health risks are often assumed to have a positive impact on the wild salmon industry and a negative impact on the farmed salmon industry. However, as press coverage often fails to distinguish between farmed and wild salmon, these claims may negatively affect demand for both farmed and wild salmon, and more generally misinform and confuse consumers.

Recent advances in biotechnology may hold the key for future expansion of the salmon aquaculture industry. Transgenic technology in particular could provide the means for the development of genetically superior broodstocks exhibiting faster growth rates, improved feed conversion efficiencies, disease resistance, the ability to utilize vegetable protein diets and tolerance to low oxygen levels and water temperatures.

Environmental organizations and consumer groups have already expressed their concerns on the potential deleterious effect of escaped transgenic salmon on wild salmon populations (Reichhardt 2000). Members of the salmon farming industry have also expressed an unwillingness to pursue transgenic salmon production. The controversy surrounding genetically modified salmon will likely continue well into the foreseeable future.

World Salmon Production and Markets

The tremendous growth in salmon farming has had a dramatic effect on world salmon production, markets, and prices. Between 1980 and 2004, world salmon supply more than quadrupled from less than 550,000 mt to more than 2.4 million mt. Major sources of supply include wild salmon from the United States, Canada, Japan and Russia and farmed salmon and salmon trout from Norway, Chile, Canada, Scotland and elsewhere. (Salmon trout is also known as steelhead or sea-run rainbow trout. It is not caught commercially.)

North American wild salmon catches increased from about 300,000 mt in 1980 to a peak of more than 500,000 mt in 1990, and then declined to about 400,000 mt in 2004 (Figure 11). During this period, primarily because of the growth of farmed salmon production, North American wild salmon declined from more than one-half to about one-sixth of world production. The declining share of North American wild salmon in world salmon production is reflected in similarly dramatic declines in the share of North American wild salmon in all major salmon markets except for canned markets and salmon roe markets.

Japanese and Russian wild salmon catches more than doubled from less than 250,000 mt in 1980 to more than 500,000 mt in 1996, and have remained at about that level. Since 1996, Japanese and Russian wild salmon catches have exceeded North American wild salmon catches. Japanese catches are generally ranched chum salmon.

Farmed salmon and trout production in 2001 totalled 1,500,000 mt. In 2004, farmed salmon and trout accounted for five-sixths of world supply.

World salmon consumption may be generally divided among five major markets: the Japanese fresh and frozen market, the European Union fresh and frozen market, the U.S. fresh and frozen market, canned salmon markets, and numerous other smaller markets.[1]

Until recently, the Japanese fresh and frozen salmon market was the world's largest market. Japan consumes very large volumes of wild salmon, including both Japanese ranched salmon as well as wild salmon imported from North America and Russia. Since the late 1980s, Japanese imports of North American wild salmon have declined dramatically, reflecting lower North American sockeye salmon catches and changing markets. In contrast, Japanese imports of Russian salmon increased, as an increasing share of Russian production was exported following the collapse of the USSR.

The rapidly growing EU fresh and frozen market now consumes more salmon than Japan. Almost all of the salmon sold in the EU market is farmed salmon.

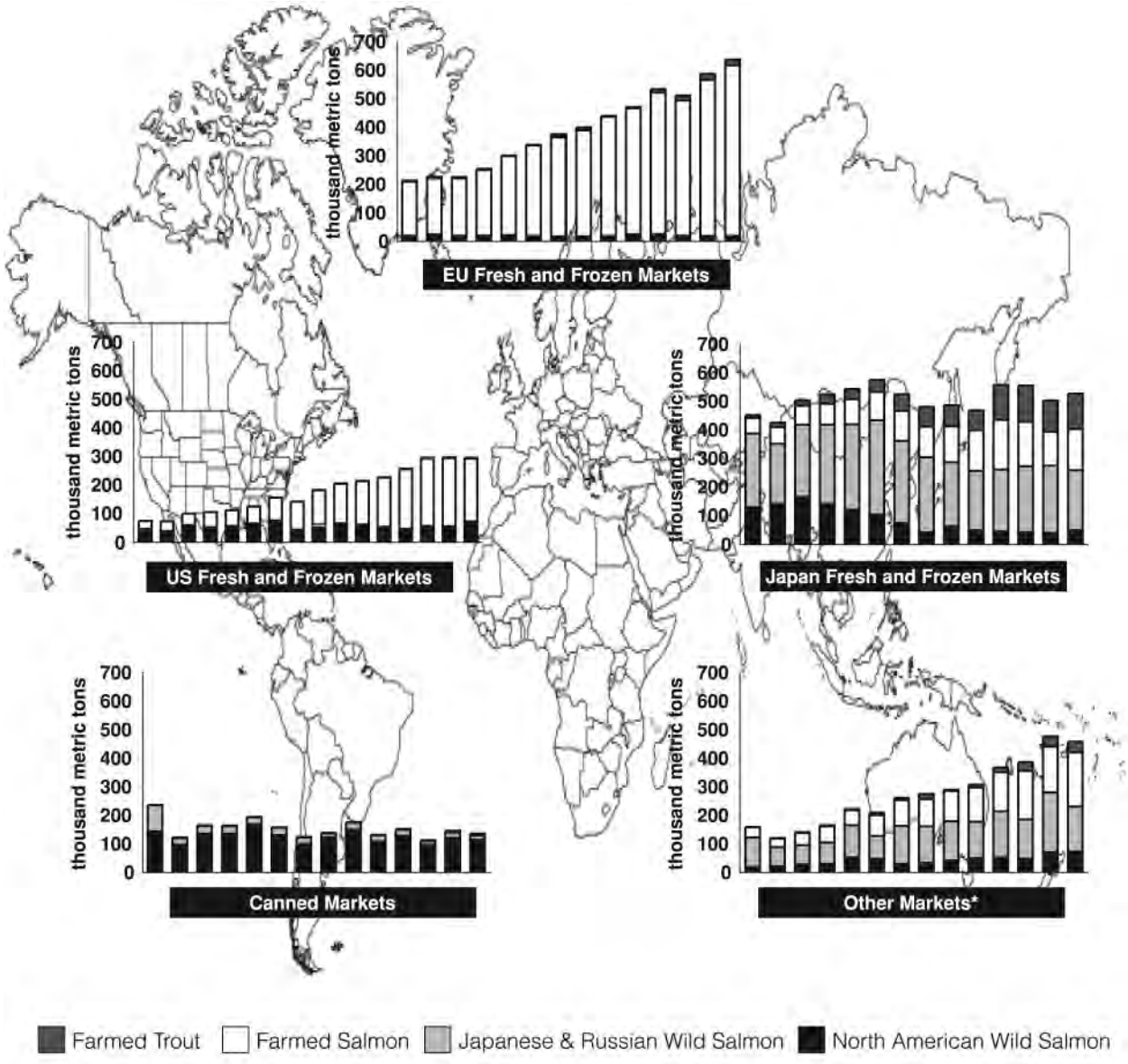
Total U.S. fresh and frozen salmon consumption has been rising rapidly with increasing imports of farmed salmon. However, in 2004, U.S. fresh and frozen salmon consumption was only about half that of Japan or the European Union.

World canned salmon production, which fluctuates from year to year, has been gradually declining. Most canned salmon is North American wild salmon.

All four major salmon markets are important for North

[1] The estimates of salmon consumption in major markets are based on numerous data sources (some of which are incomplete or conflicting) and other assumptions documented in the report. Estimates may very slightly between graphs because of differences in assumptions for different levels of aggregation across countries and species.

Figure 11 **Estimated World Salmon Consumption 1989-2004**



*Note: estimates of consumption in other markets are highly sensitive to yield assumptions and are less reliable than other estimates shown.

American wild salmon. Canned salmon markets account for the largest share of North American salmon production, followed by the U.S. fresh and frozen market. The Japanese fresh and frozen market, which formerly accounted for the largest share of North American wild salmon production, now accounts for the third largest share, followed by the European fresh and frozen market.

Consumption of farmed salmon grew dramatically between 1989 and 2004 in all markets except for canned salmon. In both relative and absolute terms, the growth in consumption was greatest in the European fresh and frozen market. The European Union accounted for about 50 percent of the increase in world farmed salmon consumption during this period, the United States accounted for 20 percent and Japan accounted for 11 percent.

It is important to note that the U.S. fresh and frozen market ranks behind other markets in importance for both wild and farmed salmon. Competition between North American wild salmon and farmed salmon is occurring in multiple markets, which are subject to different trends in both supply and demand. The effects of this competition can only be understood by

examining *all* of these markets, not just the U.S. fresh and frozen salmon market.

Wholesale price trends differ in different major markets. In general, in both the United States and the European fresh and frozen markets, prices for both farmed and wild salmon declined significantly from the early 1990s until 2002 or 2003, after which prices began to rise. In the Japanese fresh and frozen market and in the canned salmon market, prices also fell during the 1990s, but have not recovered in recent years.

Salmon prices are affected by many different factors in complex ways. Prices vary widely for different products, species and markets. For example, U.S. wholesale prices for fresh farmed Atlantic salmon fillets are typically higher than for fresh whole farmed Atlantic salmon, because of the greater cost of processing and greater convenience to consumers. In turn, fresh whole farmed Atlantic salmon command higher wholesale prices than frozen wild chum salmon because they are considered a higher quality product.

Within any given year, there is significant variation in prices from month to month, reflecting seasonal variations in demand and supply. Within any given year, U.S. wholesale prices of fresh farmed salmon may vary by as much as $.50/lb or more. Prices for fresh wild salmon prices typically fall during the season as catches increase.

In general, longer-term trends in wholesale prices reflect longer-term trends in demand and supply for different markets. Prices have tended to decline when supply was growing faster than demand, and to rise when demand was growing faster than supply.

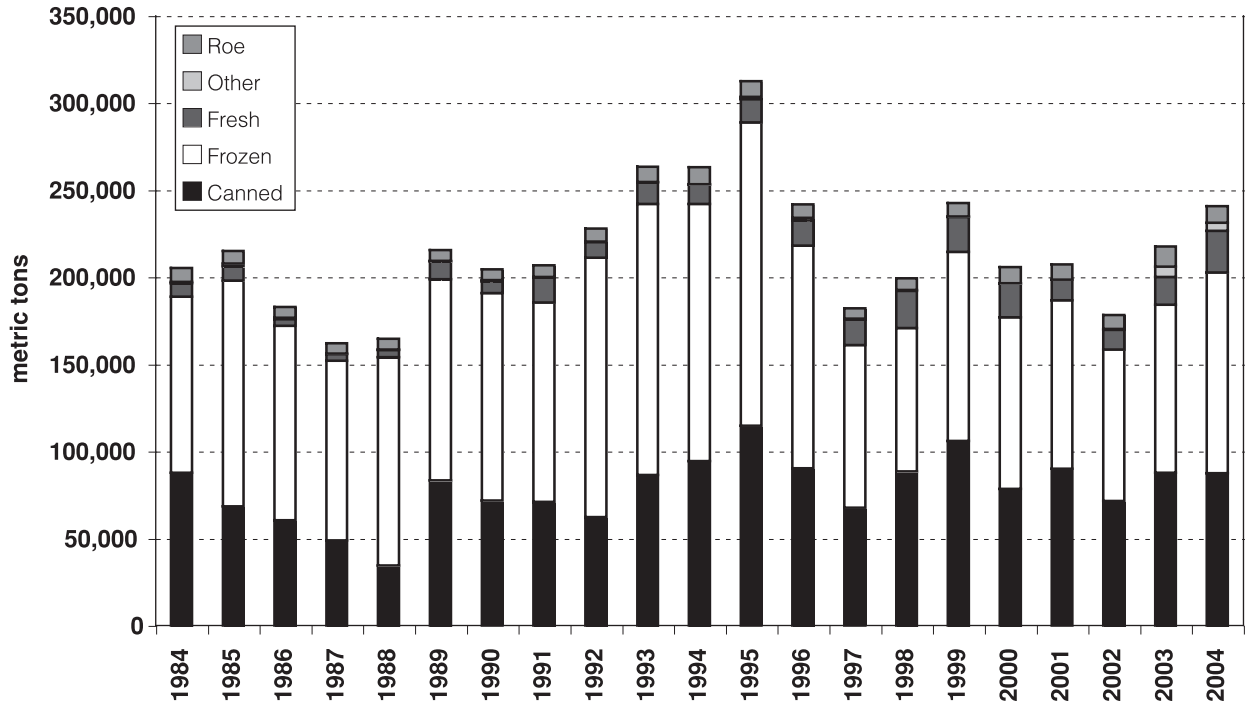
North American Wild Salmon Products and Markets

North American wild salmon are processed into four major primary products: canned salmon, frozen salmon, fresh salmon and salmon roe (eggs). Of these, canned and frozen salmon account for most of the production volume, while a much smaller share of production is sold fresh. Although the total volume of roe production is relatively low, in recent years roe has accounted for about one-quarter of the total first wholesale value of Alaska salmon products (Figure 12).

There are important differences between species in the volume of production and the relative importance of different end-markets (Table 2). Pink, sockeye and chum salmon account for the largest shares of total production. The most important market for the pink salmon is the U.S. canned salmon market. The most important market for sockeye salmon is the Japanese frozen salmon market. The most important market for chum salmon is the U.S. frozen market.

Less than one fifth of U.S. wild salmon is sold fresh or

Figure 12 **Alaska Salmon Production Volume, 1984-2004**



Source: Alaska Department of Fish and Game, Commercial Operator Annual Reports.

Table 2 **Most Important Products and End Markets for Wild Salmon**

Species	Most important products	Most important markets
Chinook	Frozen	United States
	Fresh	United States
Sockeye	Frozen	Japan
	Canned	United Kingdom
Coho	Frozen	Japan
	Fresh	United States
Pink	Canned	United States
	Frozen	United States
Chum	Roe	Japan
	Frozen	United States
	Fresh	United States

Table 3 **Estimated End-Market Shares for U.S. Wild Salmon Production, 2000-2004, by Nature of Competition with Farmed Salmon**

	Nature of competition with farmed salmon			
	Relatively little competition from farmed salmon	Competition with farmed salmon in foreign markets	Competition with farmed salmon in U.S. domestic market	
Species	Canned markets	Export fresh & frozen markets	US fresh & frozen markets	TOTAL
Chinook	1%	13%	87%	100%
Sockeye	35%	53%	12%	100%
Coho	9%	50%	41%	100%
Pink	70%	26%	4%	100%
Chum	7%	52%	41%	100%
TOTAL	**40%**	**42%**	**17%**	**100%**

Note: Shares for individual species may be biased to the extent that exports were reported as "unspecified."
Source: Table VII-8.

frozen in the U.S. domestic market, where it is subject to direct competition from U.S. imports of fresh farmed salmon (Table 3). More than twice as much U.S. fresh and frozen wild salmon is exported than sold in the U.S. domestic market. Thus, much of the competition between U.S. wild salmon and farmed salmon is occurring in Japan rather than the U.S. market. More than two-fifths of U.S. wild salmon is sold in canned salmon markets where it has faced relatively little competition from farmed salmon

The mix of products produced from wild salmon represents an important difference between wild and farmed salmon, which is mostly sold as a fresh product in the United States, Europe and Japan. Although significant volumes of frozen farmed salmon are sold to Japan, very little is sold to Japan in canned form. There is very little roe production from farmed salmon.

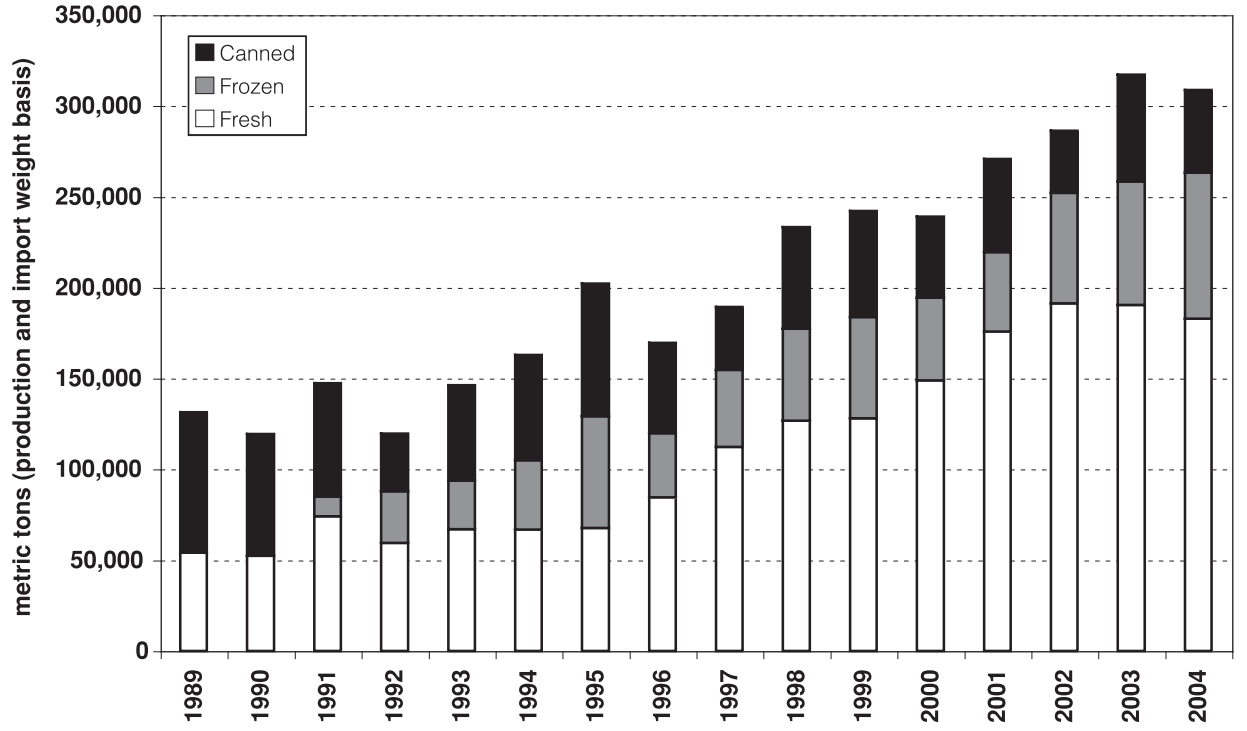
United States Salmon Consumption

Between 2000 and 2004, the United States consumed about 284,000 mt of salmon annually.[2] Fresh salmon accounted for about 63 percent of total U.S. consumption, frozen salmon accounted for about 21 percent, and canned salmon accounted for about 16 percent. About two-thirds of U.S. salmon consumption was imported and about one third was domestic. About two-thirds was farmed and about one-third was wild. Almost all of the farmed salmon was Atlantic salmon; almost all of the wild salmon was Pacific salmon.

Estimated total U.S. salmon consumption more than doubled from less than 150,000 mt in 1989 to more than 300,000 mt in 2004 (Figure 13). Most of the growth in U.S. salmon consumption was due to rapid and sustained growth in consumption of fresh salmon.

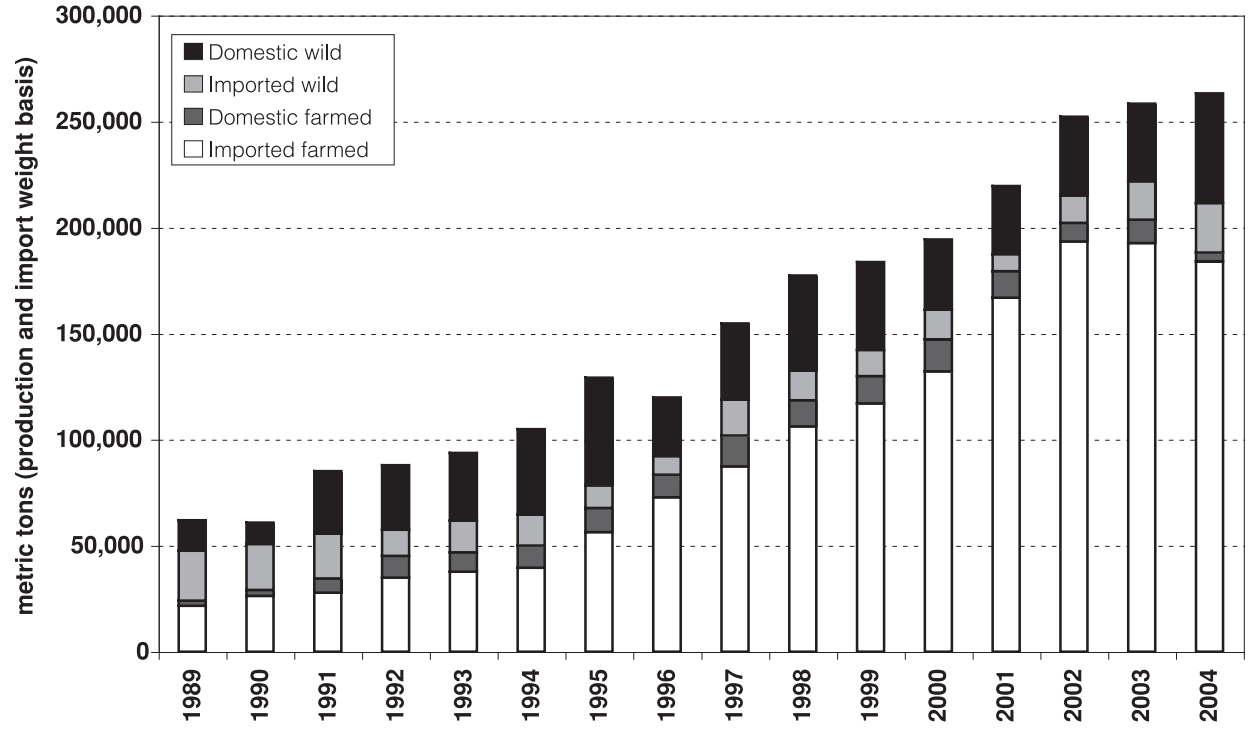
[2] No data are collected on U.S. salmon consumption. The report presents estimates of U.S. salmon consumption derived from data for U.S. salmon production, imports and exports. These estimates are more reliable for longer term trends than for consumption of specific species in specific years.

Figure 13 **Estimated United States Salmon Consumption: Canned, Frozen & Fresh**



Source: Estimated using the United States Salmon Market Database described in Appendix C.

Figure 14 **Estimated United States Fresh and Frozen Salmon Consumption: Wild & Farmed**



Source: Estimated using the United States Salmon Market Database described in Appendix C.

Most of the growth in U.S. consumption of fresh and frozen salmon was driven by rapidly rising imports of farmed salmon. Between 1989 and 2002, estimated U.S. annual average consumption of farmed salmon increased eight-fold, from less than 25,000 mt to more than 200,000 mt (Figure 14). During this period U.S. wild salmon consumption also increased. Thus the growth in farmed salmon consumption was not driven by substitution by consumers of farmed salmon for wild salmon. Rather, it was driven by expansion in the fresh and frozen salmon market, in particular by introducing fresh farmed salmon to markets in which wild salmon had not been available, such as the U.S. Midwest and Southeast.

Canned salmon is also an important part of U.S. salmon consumption. Consumption is mostly canned pink salmon, and varies from year to year, usually between 30,000 and 60,000 mt, reflecting variation in wild salmon catches. Canned salmon sells into a very different market than fresh and frozen salmon; it is bought by different consumers at different prices for different uses. Until recently, very little farmed salmon was canned, and farmed salmon has had relatively little effect on canned salmon prices.

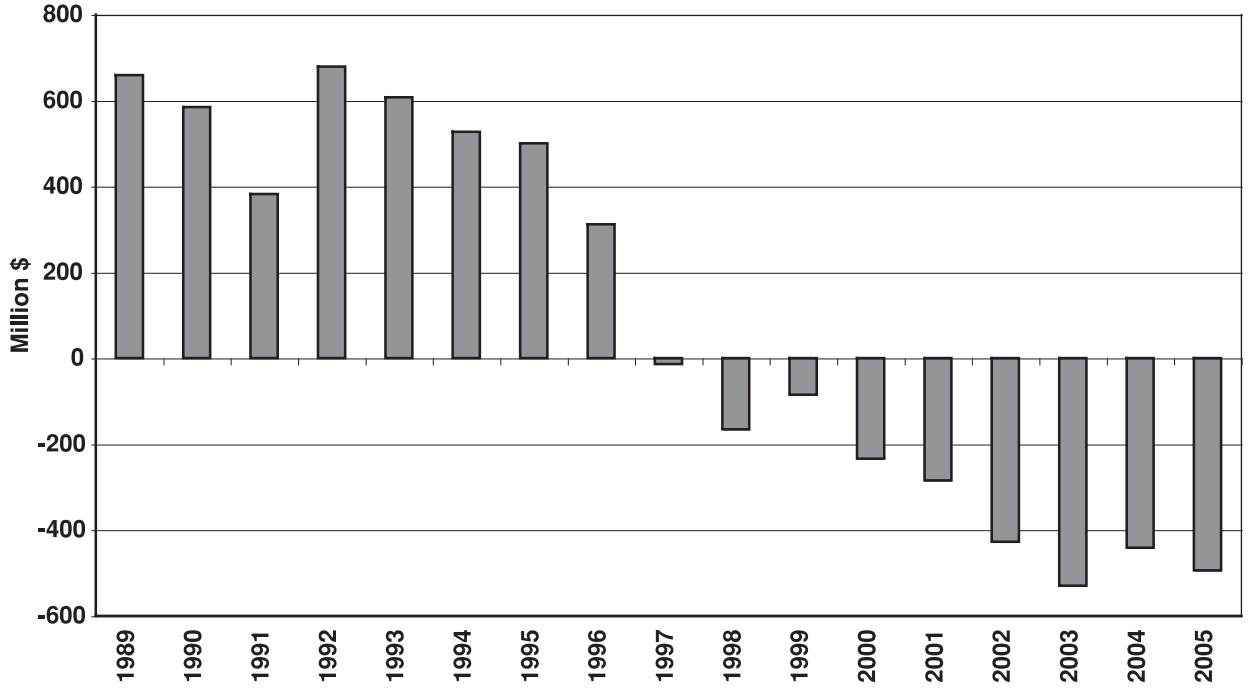
There are important differences between the five species of wild Pacific salmon in total volume consumed and the mix of products consumed. For example: frozen salmon accounted for the largest share of consumption of sockeye salmon, coho salmon, and chum salmon; fresh salmon accounted for the largest share of chinook salmon consumption. These differences between consumption patterns for different species are important. Not all wild salmon is the same: different species are sold in different product forms and compete in different ways with farmed salmon in the U.S. market.

United States Salmon Trade

Between the late 1980s and 2003, the United States transitioned from being a net exporter of salmon products to a net importer of salmon products. In 1989, the United States had a salmon trade surplus of just over $650 million. This surplus disappeared in a two-year period; between 1995 and 1997 the net trade balance in salmon products changed from a $500 million surplus to a $14 million trade deficit (Figure 15). The deficit grew nearly 40 times larger between 1997 and 2003 to a value of $530 million. Because of declining salmon prices, the deficit decreased in 2004 to nearly $440 million but it grew again in 2005 to reach $494 million.

The changing trade balance is attributable to long-term

Figure 15 **U.S. Salmon Trade Balance 1989-2005**



Species included are Atlantic, Chinook, Chum, Coho, Pink, and Sockeye. Products forms include Fresh, Frozen, Canned, Salted, Smoked, Preserved, and Roe.

Source: USDC/NMFS (2006)

trends in both U.S. exports and imports of salmon products. In general, foreign salmon producers initiated this shift through the creation of inexpensive, consistent, high-quality farmed salmon products. In particular, growth in U.S. imports of salmon has been primarily driven by the surge in imported quantities of fresh and frozen fillets. In 1994/1995, Chilean farmers introduced salmon fillets with the pin bones removed (PBO), a technological innovation that set the stage for the explosive growth in salmon imports seen in recent years. Fillets were priced lower than whole fish before the introduction of the PBO technology. Today, boneless fillets command a price premium over whole fish. The traditional wild salmon industry in the United States has been slow to adapt and has found itself relegated from having a dominant market share to a secondary position.

Another underlying factor influencing both exports and imports is the limitation and variability of North American wild salmon production. Salmon import data reflect smooth steady increases each and every year since 1992. Salmon exports, by contrast, show yearly variability. With imports steadily increasing and U.S. landings varying around a relatively stable mean, the total U.S. supply of fresh and frozen salmon products has been increasing.

Canada and Chile hold dominant positions in overall quantity and value of U.S. imports. In value terms, these countries accounted for 34 percent and 51 percent of imports, respectively, in 2005. However, each country specializes in exporting a different product to the United States. Canada dominates the U.S. import market for whole salmon, while Chile dominates the U.S. market for Atlantic salmon fillets.

On average, fresh salmon and salmon trout products account for 80 percent of total imports in terms of both quantity and value. Fresh products comprised most of the increase in salmon imports over the last 10 years, but imports of frozen salmon as well other product forms such as smoked and canned salmon have also increased. In 2003 and 2004, declines in imported quantities of fresh products were compensated with increases in imports of frozen products.

The United States Salmon Distribution System

Salmon are distributed from fishermen or fish farmers to U.S. consumers in many ways. Participants in the salmon distribution system include primary processors, importers, secondary processors, broadline distributors, specialty seafood distributors, brokers, traders and many different kinds of retail and food service companies. Many companies perform multiple distribution functions.

Only a relatively small share of salmon are sold directly from fishermen to consumers, usually in fishing ports or nearby. Selling directly to consumers is not a practical option for most fishermen, because most salmon fishing occurs in remote locations hundreds or thousands of miles away from most potential consumers, and because fishermen are busy fishing during salmon season.

In recent years, this distribution system for both wild and farmed salmon has evolved in many ways, the most important involving business consolidations. For example, the retail and food service industries are becoming more concentrated, with large retail and food service chains accounting for a larger share of total sales to consumers. These large buyers are able to reduce costs through economies of scale, including buying in large volumes. The salmon distribution system is similarly becoming more concentrated, with fewer and larger distributors handling an increasing share of total volume, and an increasing share of salmon being sold directly to large retail and food service chains by large fish-farming companies and large wild salmon processors.

As salmon moves through the distribution system from fisherman or fish farmers to the consumer, prices increase. A consumer may pay $15.99 per pound for a final salmon product for which the fisherman was paid $0.59 per pound. Many fishermen and many consumers cannot understand why the price should not be higher for the fishermen, lower for the consumer, or both. One factor contributing to the markup in price per pound is loss in weight during processing: the weight purchased by consumers may be less than half the weight delivered by fishermen. Other factors include the numerous labor-intensive steps in the distribution system, all of which add costs; the financial risks in handling fresh fish with limited shelf lives and in selling to markets in which prices can change rapidly, and the fact that a relatively small share of a fisherman's catch is likely to go to the highest quality markets commanding premium retail prices.

United States Salmon Consumers

There is no comprehensive source of information about U.S. salmon consumers. The report reviews eight consumer surveys which provide insights about U.S. salmon consumers. The surveys were conducted by different organizations for different purposes in different parts of the United States over a 15-year period. They differed in how they screened for respondents, so the responses reflect consumption, preferences and opinions of different kinds of consumers. They asked different kinds of questions. While these factors make it difficult to compare responses across the surveys, certain broad conclusions may be drawn.

American consumers vary widely in their frequency of salmon consumption. Some consumers—probably less than 20 percent of all Americans—eat salmon frequently (more than once a month). Other consumers—at least 30 percent of all Americans—never eat salmon. The remainder are somewhat evenly divided between those who eat salmon somewhat frequently (twice per year or more) and rarely (less than twice per year).

American consumers eat salmon both at home and in restaurants. It is likely that the frequency of salmon consumption increased during the 1990s both at home and in restaurants, but that at-home consumption may have increased relatively more rapidly.

According to several surveys, the frequency of salmon consumption increases with income. Rates of fresh and frozen salmon consumption tend to be higher in Pacific Coast states than they are in other parts of the country; the Northeast is a close second. Growth in farmed salmon consumption has been relatively greater in the South Atlantic region than in other regions, perhaps because this region is closer to Miami, where much of the farmed salmon imported from Chile enters the United States. These survey results indicate that farmed salmon created markets which had previously not existed to any large extent.

Survey results—now several years old—suggest that just under one-fifth of American salmon consumers have heard of farmed salmon, are aware that farmed and wild salmon are different, and consider wild salmon preferable. Of the remaining four-fifths of consumers, a small segment considers farmed salmon specifically preferable to wild. But most salmon consumers either have not heard of farmed salmon or do not have an opinion about differences between farmed and wild salmon. (Consumer knowledge and opinions may have changed somewhat since these surveys were conducted.)

Clearly, there is no "typical" American salmon consumer. Consumers vary widely in how much salmon they buy, what they buy, where they buy it, and why they buy it. Information about wild and farmed salmon is likely to affect consumers' purchase decisions in different ways. This suggests that there is no single best marketing strategy for wild or farmed salmon. Different strategies will have different effects on different consumers in different markets.

Salmon Marketing

Since wild and farmed salmon prices began to decline in the early 1990s, fishermen, processors, policy makers and consultants have debated how to address the problems facing the wild salmon industry. A series of task forces, industry forums and reports have examined the issues and made recommendations about strategies for the industry. In general, they have concluded that the wild salmon industry has been a production-driven commodity industry, overly dependent on the canned salmon market and the Japanese frozen market, which has devoted insufficient attention to quality, development of new products and marketing. Therefore, to compete effectively with farmed salmon in a changing market, the wild salmon industry needs to improve quality, develop new products to respond to new market demand and opportunities, devote significantly more resources to marketing (particularly in the U.S. fresh and frozen market), reduce harvest and processing costs and market in more effective ways.

Although the industry has made progress in recent years, significant quality problems remain in many North American wild salmon fisheries, such as net-marks, external and internal bruising, and softness or mushiness. These problems typically result from lack of careful handling or temperature control after fish are caught. While there has been general agreement about the goal of improving quality, there has not been agreement about how to achieve this goal, and whether quality standards should be voluntary or mandatory. More recently, some producers have established their own quality standards, which are monitored and certified by external certifying organizations.

However, as with improving quality, there has not been agreement about how to improve the marketing of Alaska wild salmon or how to fund such efforts. The industry continues to debate this issue, and to experiment with new approaches to marketing, such as regional marketing organizations.

Adding to the challenges of marketing wild salmon is the fact that the wild salmon industry is a highly competitive industry. Within the wild salmon industry, salmon sellers compete for customers, and salmon buyers compete for suppliers. On a broader scale, competition occurs between species, regions and countries. Different Alaska regions, such as Copper River and Cook Inlet, compete to create reputations and brands for their products. Canadian wild salmon competes with Alaska wild salmon in the United States and abroad. Salmon from Washington, Oregon and California compete against each other and against salmon from British Columbia and Alaska.

Natural wild salmon further competes with hatchery wild salmon. Some fishermen in regions without hatcheries, such as interior and western Alaska, have argued that Alaska salmon hatcheries have depressed prices for Alaska pink and chum salmon by producing too many fish. Some argue their markets would be better if hatcheries produced less fish.

Beyond competition in the marketplace, there are many other conflicts within the wild salmon industry which

make it more difficult to achieve cooperation in marketing. One set of conflicts is between fishermen and processors over prices paid to fishermen. In many wild salmon fisheries, fishermen believe that they are not paid fairly by processors. A long-standing history of mistrust has included fishermen's strikes and lawsuits alleging price-fixing by salmon processors. This conflict hampers cooperation among fishermen and processors over how to market wild salmon effectively.

Marketing costs money, and effective marketing requires sustained funding over multiple years. The dramatic decline in the value of wild salmon catches and production has made it harder for the wild salmon industry to fund marketing efforts. In Alaska, a decline in state oil revenues contributed to a decline in state funding for salmon marketing. However, in recent years substantial federal funding has been provided to Alaska wild salmon marketing efforts.

The farmed salmon industry has also engaged in marketing campaigns, and is increasingly doing so in reaction to negative publicity regarding their product. Negative campaigns against farmed salmon do not necessarily bode well for wild salmon products, as press reports do not always distinguish between farmed and wild products, and may serve to convey a negative image of "salmon" to consumers.

Effects of Farmed Salmon on Wild Salmon Prices

It is difficult to quantify specific effects of farmed salmon on wild salmon prices over time, because of the variety and complexity of salmon markets, as well as the rapidity of changes that have occurred in these markets. Different wild salmon species and markets have been affected in different ways by farmed salmon. Generalizations about effects of farmed salmon on "wild" salmon prices risk being overly simplistic and misleading.

The most important factor driving change in world salmon prices has been rapid and sustained growth in world farmed salmon and salmon trout production. This has fundamentally transformed world salmon markets—not only because of the dramatic growth in total supply, but also because of the changes that it has represented in the kinds of salmon products which are available, the timing of production, market quality standards and organization of the industry.

During the 1990s the rapid growth of farmed salmon supply depressed prices not only for farmed salmon but also in most traditional wild salmon markets. More recently, prices for farmed and wild salmon have stabilized or increased. Wholesale price trends for farmed and wild salmon appear less closely correlated than formerly, suggesting that differentiation is occurring in markets for wild and farmed salmon. Some wild salmon products sell for lower prices than farmed salmon, while others command price premiums.

Many other factors besides farmed salmon have also affected wild salmon prices. These include:

- Increasing concentration in the retail and food service industries
- Increased world pink and chum salmon harvests
- Following the collapse of the Soviet Union, the emergence of Russian wild salmon as a significant competitor to North American wild salmon in the Japanese frozen market and world canned salmon and salmon roe markets
- Declining consumer demand for canned salmon
- The end of the Japanese "bubble" economy of the 1980s and a stubborn economic recession in Japan, historically the most valuable market for North American fresh and frozen wild salmon.

The introduction of salmon farming has also changed salmon market dynamics in several important ways. As farmed production becomes an ever-larger share of total supply, wild salmon prices are driven more and more by farmed salmon supply rather than by wild salmon supply because wild salmon becomes a small player in the market. This has meant that wild salmon fishermen can no longer count on a low catch being offset in part or in full by higher prices. Although an inverse relationship between wild catch and prices still exists, it is muted by the larger market.

Economic and Social Effects of Changes in Wild Salmon Markets

Commercial salmon fishing, tendering and processing contribute to the economic livelihoods of tens of thousands of people and dozens of coastal communities from California to Alaska. Salmon fishing is also a way of life, defined in part by independence, tradition and the beauty and wildness of the environment in which people work and live.

The decline in value of wild salmon catches beginning in the early 1990s had wide-ranging economic and social effects on people and communities dependent on wild salmon fisheries. Many fishermen experienced a dramatic decline in income, as well as losses in the value of permits and boats and difficulties in loan payments for permits and boats. Many stopped fishing.

Many salmon processing plants have closed, resulting in job losses for plant workers, lost markets for fishermen, and declining tax bases for communities. Communities have also lost revenues from salmon business taxes based on the value of catches.

Other wide-ranging economic and social effects

include increased difficulty in finding experienced fishing crew; migration of young people and fishing families out of fishing communities in search of other work; and political pressures for reallocation of fishery resources from commercial to sport fisheries.

The nature and significance of these effects vary widely between regions, fisheries and individuals. In some areas, economic and social stresses caused by loss in value of salmon catches have been exacerbated by other factors, such as changes in prices and catches for other fisheries, changes in fisheries management and, in parts of Alaska, the Exxon Valdez oil spill.

Effect of Salmon Farming on North American Wild Salmon Resources

How salmon farming may affect wild salmon resources is a complex and uncertain topic. Salmon farming may have both direct and indirect effects on wild salmon resources. Direct effects may result from interactions in the environment between farmed salmon operations and wild salmon. Indirect effects may result from changes in market conditions, which may in turn affect wild salmon catches, commercial hatchery releases and political support for fisheries management and habitat protection.

There is little evidence that salmon farming has had significant direct effects to date on North American wild salmon resources. Most effects which may have occurred to date have likely been localized effects on wild salmon migrating near salmon farms. Much of the public debate about the effects of salmon farming has focused on the nature of potential risks to wild salmon populations, and acceptable levels of risk. The evidence related to many of these potential risks is inconclusive because of insufficient data and research.

Potential direct effects that salmon farming might have on wild salmon resources also depends on the proximity of salmon farms to wild salmon migration routes. North American salmon farming operations are concentrated in relatively small areas compared to the range of North American wild salmon resources. The largest wild salmon runs, in Alaska, are located great distances from any salmon farms where there exists a permanent moratorium on salmon farming.

There is also little evidence to suggest that salmon farming may have indirectly benefited wild salmon resources, by reducing prices and thus economic incentives to "overharvest" wild salmon. Lower prices have not necessarily led to lower catches of wild salmon. Where some fishermen have quit fishing, those who remain have caught more fish at lower average cost. Nor would lower catches necessarily benefit wild salmon resources, since most commercial wild salmon fisheries are managed sustainably and are not being "overharvested."

Salmon Trade Policy

Trade policy has not been used extensively to limit the importation of farmed salmon into the U.S. market, with the exception of two legal actions brought against Chile and Norway by U.S. farmed salmon producers. The primary exporters of salmon to the United States (Canada, Chile, Scotland and Norway) are all signatories to the General Agreement on Tariffs and Trade (GATT), and members of the World Trade Organization (WTO). Canada is part of the North American Free Trade Agreement (NAFTA), and the United States has recently signed a free trade agreement with Chile. There has been relative trade harmony amongst these nations with respect to salmon. Most salmon products imported by the United States enter free of any harmonized tariffs, although some processed salmon carry tariffs, and some farmed salmon enter under countervailing or anti-dumping duties.

As mentioned above, over the past two decades, the U.S. farmed salmon industry has twice petitioned the U.S. International Trade Commission (ITC), under the Department of Commerce to impose trade restrictions in the form of anti-dumping and countervailing duties. The intent of these duties is to increase the price of salmon imports and limit 'unfair' competition from imports. In 1989, falling prices of salmon in the U.S. market led the Coalition for Fair Atlantic Salmon Trade, a U.S. farmed salmon industry group, to file a petition alleging that Norwegian producers had received unfair subsidies and were also dumping salmon in the U.S. market. The ITC investigated the practices of the Norwegian salmon producers and agreed, ruling in 1990 that Norwegian Salmon farmers were dumping salmon and receiving a countervailable subsidy (Anderson 1997). These relatively high duties caused Norwegian salmon products to become uncompetitive in the U.S. market. Farmed salmon from Chilean and Canadian producers rapidly took Norway's place. Norwegian shipments to Japan also increased, reducing the market share that traditionally corresponded to U.S. exporters. U.S. salmon prices did not change appreciably.

In 1997, the Coalition filed another petition alleging that Chilean exports of Atlantic salmon products to the United States were injuring the U.S. farmed salmon industry because they were subsidized and being sold at less than fair value. The ITC again investigated and determined that there was evidence of both countervailable subsidies and salmon product dumping (Federal Register 1997a). The margins were determined to be quite small, and the companies received duties ranging between 2.24 percent and 10.91 percent. These duties had little effect on the growth of U.S. imports of Chilean salmon, especially fresh fillets.

As in the Norwegian case, prices did not improve; in particular, the price of whole fresh salmon continued to trend downward. Both the Norwegian and Chilean cases were time consuming and costly, and did little to enhance price.

Although trade measures have been discussed within the wild salmon industry from time to time as a potential measure to increase prices, the wild salmon industry has not initiated any petitions.

MSC Certification of Alaska Salmon

Eco-labeling programs evaluate the production process of a fishery with regard to established environmental standards set by an independent third party. If the process meets these standards, the producer or marketer may buy a license to use a specific eco-label in marketing efforts. In effect, the label conveys to the consumer information concerning a product's environmental impact. The consumer is then able to choose among product alternatives, eco-labeled and not. In theory, if the consumer perceives benefits from seafood from sustainable fisheries, then the consumer will pay a premium for that product, creating a market-based incentive for the fishery to become and remain certified, and for other fisheries to do the same.

The Marine Stewardship Council (MSC) was created in 1996 through a cooperative effort of the World Wildlife Fund (WWF) and Unilever, a multi-national corporation. The goal of the partnership was to provide a standardized mechanism for certifying and labeling sustainable seafood products from wild fisheries worldwide, thereby providing a market-based incentive to maintain sustainable fish stocks. The MSC has been independent from WWF and Unilever for several years.

The Alaska salmon fishery was originally assessed as a test case, with funding for the assessment provided by the Alaska Department of Fish and Game, and became certified in 2000. The evaluation and certification included the entire fishery, with all species and gear types in all of Alaska as one fishery. Among the primary concerns raised by stakeholders was the environmental and genetic impact of the use of extensive hatchery programs in Alaska to enhance salmon populations. Certification is only in place for five years, after which the fishery must go through a re-certification process. Alaska is currently pursuing re-certification by the MSC, although certification is now being processed for 16 separate management areas, in contrast to the earlier assessment.

The British Columbia salmon fishery is also being assessed for potential certification, but the process has moved forward on a river-by-river, species-by-species, gear-by-gear basis. This assessment is expected to be of long duration. In California, in 2002, the California Department of Food and Agriculture awarded the California Salmon Council a grant for a pilot project seeking to certify California king (chinook) salmon fishery under the MSC program. A full assessment began in April 2004 for the troll-caught chinook salmon fishery.

The market impact of the MSC certification on Alaskan salmon markets remains uncertain. In part because the program remains new, there are no existing studies of the price impacts of MSC labeling on product prices. Estimates are that less than 10 percent of Alaska's total salmon catch is being marketed globally with the MSC label. Initial anecdotal evidence and evaluations of market impacts indicate that MSC-certified Alaskan salmon is being sold in many European markets, although less appears to be sold in the U.S. market.

Seafood Labeling Programs

In addition to eco-labels, seafood consumers are being introduced to other new labeling. Labeling is an example of how industries in increasingly competitive global markets look for new ways to differentiate themselves from the competition.

New mandatory labels identifying country-of-origin and whether the salmon was farmed or wild were in place as of April 2005. Restaurants are exempt. To obtain a "U.S. Product" label, farmed seafood must be hatched, raised, harvested and processed in the United States. Wild-caught seafood must be caught in the waters of the United States or by a U.S.-flagged vessel, and also must be processed in the United States or aboard a U.S.-flagged vessel. Under this definition, hatchery salmon are considered wild.

Costs to producers of supplying country-of-origin labeling are non-trivial and uncertain. The major cost comes from maintaining traceability of the product from production to the retail outlet. Several sources of costs to retailers apply particularly to the seafood industry.

Other labeling standards that may affect the wild and farmed salmon industries include a U.S. Food and Drug Administration (FDA) requirement that retailers label food containing color additives, and organic standards for wild fish and farmed fish being drafted by the USDA. The organic standards will be created within an environment of significant controversy, as the organic agricultural producers and the National Organic Standards Board are strongly opposed to certification of wild fish as organic.

It is not easy to predict how U.S. consumers will react to increased labeling of salmon, whether country of origin, farmed versus wild, organic, eco-labeled or color-added. Unless consumers have strong regional preferences, country-of-origin of salmon should not have much of an impact, especially if consumers believe that U.S. authorities are doing their job ensuring that imported salmon, regardless of country of origin, meet or exceed safety standards. In addition, the most important foreign sources of salmon

(Norway, Chile, Scotland, Canada and Ireland) are not viewed as nations with poor hygienic standards. On the contrary, there are many very favorable views of these countries. However, "Buy American" continues to pull in many consumers.

Country-of-origin and organic labeling are unlikely to change the methods by which wild salmon are caught or harvested in the United States or any of the nations which are major suppliers of imported salmon. Neither are likely to improve management policies for wild salmon or are likely to make wild salmon more sustainable. Rather, the primary positive impacts of such labeling programs may occur in supplies of farmed salmon. As the EU continues to certify organic farmed salmon, fewer antibiotics and other chemicals will be used in the farmed salmon industry. As more focus is put on the country-of-origin of farmed salmon, there may be more effort on the part of farmed salmon exporting nations to ensure that the environment around farming areas are pristine, and to perform better in ratings of environmental groups.

However, the label "wild" salmon appears to be very important in the market at the moment. While producers, wholesalers and retailers are generally not using the MSC logo in their marketing materials for wild salmon, they are highlighting the fact that their product is wild. Restaurants and supermarkets, both chains and independents, are also emphasizing that Alaska salmon is a wild product. This is likely contributing to higher prices for the higher-valued wild salmon species: chinook, coho and sockeye.

Future of Salmon Aquaculture in North America

Based on observed trends, future growth in worldwide demand for salmonid products will be satisfied by modern aquaculture rather than increased harvests of wild salmon stocks. Salmon aquaculture is predicted to continue to develop in Northern Europe as well as North America (particularly Canada), but currently Chile has the greatest potential for growth. Aquaculture offers great advantages over capture fisheries, such as consistency of supply, year-round availability, greater quality control and the possibility of longer-term contracts. In addition, the aquaculture industry is more attentive to and has a greater capacity to respond to market demands. As such, large restaurant chains and supermarkets will increasingly source their salmon from aquaculture. Over time, wild salmon is likely to be sold increasingly either in relatively small but growing higher-end niche markets which emphasize the salmon's "wild" characteristics or in lower-end markets, such as canned fish and frozen portions, for which wild salmon enjoys a cost advantage over farmed salmon.

Although farmed salmon is likely to extend its dominance over global supply, ocean-pen salmon aquaculture in North America will continue to face numerous obstacles. Low-cost foreign producers (e.g., Chile) will present formidable competition for U.S. salmon farmers. The industry will also be subject to increased regulatory oversight (e.g., Endangered Species Act on the East Coast) and confrontation from environmental organizations on issues such as fish escapes and transfer of diseases to wild populations. Conflicts with other coastal resource users will continue to arise. Given continued strong opposition to salmon farming, Alaska's moratorium on "for-profit" ocean-pen aquaculture will not be lifted in the foreseeable future. This will limit aquaculture in Alaska to the hatcheries which are used to enhance the harvest of commercial salmon fisheries. While the U.S. ocean-pen salmon aquaculture industry could see some growth (possibly offshore or land based), it will more likely contract in the near future.

The Canadian ocean-pen aquaculture industry may see some growth in the future, but farmers will continue to struggle with stringent government regulations and opposition from environmental groups, particularly in British Columbia (PricewaterhouseCoopers 2003). Salmon pricing cycles will cause further consolidation of the industry, putting some companies out of business and forcing reorganization in the surviving firms. Currently, most Canadian salmon is exported as whole fish but more value-added processing such as PBO fillets is likely to occur in the future.

Outlook for the Future

As noted at the beginning of this Executive Summary, the report addresses numerous, wide-ranging and complex issues. The primary purpose of the report is to inform people who care about these issues—particularly policymakers, the environmental community and the fishing and fish farming industries—to provide a sound basis for achieving environmental and economic goals. Among the most important things to understand about these issues are the following:

- Historically, most North American wild salmon has been canned or exported frozen. A relatively small share has been sold fresh or frozen in the U.S. market, although this share is growing. Thus the market challenges and opportunities facing North American wild salmon cannot be understood or addressed by only thinking about the U.S. fresh and frozen market.
- High-quality fresh farmed salmon—mostly Atlantic, with smaller volumes of chinook and coho—was introduced in the 1980s into a U.S. market that primarily sold high-valued wild chinook and coho salmon in the West and low-valued wild chum and pink salmon throughout the rest of the country. Fresh farmed salmon imports

year-round drove the expansion of the market for fresh salmon and the resulting rapid growth in farmed salmon imports.

- Inherent characteristics of wild salmon fisheries—short seasons, variable and uncertain catches and remote locations—create challenges for wild salmon in meeting demands of the new world market created by fresh farmed salmon. The laws and regulations governing how salmon are harvested add to these challenges.
- The market challenges faced by North American wild salmon producers go beyond competition from farmed salmon and include other factors such as declining demand for canned salmon and the slowdown in the Japanese economy.
- U.S. trade policies are not likely to be effective tools for addressing the challenges wild salmon producers face.
- The benefits of MSC labelling to the Alaska salmon industry have not yet been clearly demonstrated. Although use of the MSC label is significant in marketing relatively small volumes of Alaska salmon in the EU, the industry has made relatively little use of the MSC label in marketing much larger volumes of Alaska salmon in the United States.
- Although farmed-versus-wild labeling appears to have benefited some Alaska salmon, the benefits to wild salmon of other labeling programs such as country-of-origin labeling, and organic labeling are less certain. Country-of-origin labeling may benefit farmed salmon as well as wild salmon. Organic labeling is more likely to benefit farmed salmon as there is minimal likelihood of the creation of U.S. organic standards for wild fish. While organic labeling may provide incentives for the farmed salmon industry to address environmental concerns related to farmed salmon production, labeling programs are unlikely to create new incentives for better management of wild salmon.
- Negative publicity regarding farmed salmon may have a short-run negative impact on farmed salmon, but will not necessarily benefit wild salmon. Negative publicity may paint both wild and farmed salmon with the same brush, especially among the majority of potential consumers who eat relatively little salmon and know little if anything about differences between farmed and wild salmon. The farmed salmon industry is working actively to address environmental and health issues raised by critics and over the longer term comparisons may not be in the interest of wild salmon.
- To date salmon farming appears to have had little effect on commercial wild salmon resources, either negative or positive. Most significant commercial salmon fisheries are located great distances from salmon farms. Lower prices caused by competition have not necessarily reduced wild salmon catches because the main limiting factors are regulatory rather than economic.

Among the most important conclusions of the report about the outlook for the future of the salmon industry are the following:

- Most future growth in world salmon supplies will occur because of aquaculture. Chile has the greatest potential for growth, although salmon aquaculture will continue to develop somewhat in northern Europe.
- Almost every imaginable aspect of salmon farming (breeding, feeding systems, disease management) will see improvements through continued investment in technology. Overall costs of production will continue their downward trend. Feed may become a greater share of total cost, leading to incentives for improvements in farmed salmon feeding systems and feed management will help to offset potential increases in feed costs simultaneously addressing some other issues of concern to some related to salmon farming.
- Although world farmed salmon production is likely to expand, ocean-pen salmon aquaculture in North America will continue to face numerous obstacles. Low-cost producers, particularly Chile, will present formidable competition for U.S. salmon farmers, who will face increased regulatory oversight and confrontation from environmental organizations on issues such as fish escapes and other issues. Conflicts with other coastal resource users will continue to arise. The moratorium on ocean-pen aquaculture in Alaska will not be lifted in the foreseeable future.
- Large restaurant chains and supermarkets—dependent on a large, consistent, year-round supply of product—are likely to increasingly source their salmon from aquaculture. As the global salmon market grows and diversifies, wild salmon is likely to be sold increasingly both in higher-end niche markets to consumers who specifically prefer wild salmon, and in canned, frozen and value-added markets where wild salmon can compete on lower costs of production.
- In the United States, niche markets for chinook, coho and sockeye will primarily develop in high-end restaurants in major cities. An important regional market will continue to develop in the U.S. Pacific Northwest states. However, these niche and regional markets will remain relatively small in comparison with total wild salmon supply.
- The highest sales volume North American outlets for wild salmon, particularly chum and pink salmon, may become valued-added processed salmon products such as salmon burger and microwavable convenience meals, and in restaurants such as fast-

food and mid-price range chains.

- The Japanese market will continue to be an important export market for North American wild salmon. In Japan, North American wild salmon will face increasing competition from farmed salmon and Russian wild salmon, and will have to meet that challenge with outstanding quality.
- Emphasis on the wild and sustainable attributes of Alaska salmon may help to expand the European market for Alaska salmon.

Recommendations:

The report offers nine recommendations to policymakers, the environmental community and the fishing and fish farming industries. These recommendations are based on the assumption that multiple goals are important in the consideration of salmon issues and policies. These goals include protection and sustainability of wild salmon resources and the marine environment; providing consumers with a wide variety of healthy, appealing and economic opportunities to consume salmon; maximization of economic, social and cultural benefits derived from North American wild salmon resources, particularly for individuals and communities traditionally dependent on wild salmon; and realizing the potential for responsible salmon farming to promote economic development both in the North America and other countries.

- **Provide accurate and balanced information about salmon**. Government, scientists, the wild and farmed salmon industries, non-governmental organizations and the press have a responsibility to provide the public with accurate and balanced information about salmon issues. Misinformation — including overly simplifying complex issues, or overstating the degree of certainty of scientific knowledge—is ultimately counter-productive, serving to confuse consumers and undermine confidence in all parties to policy debates.
- **Harmonize regulatory food safety standards**. Governments have a responsibility to provide consumers with clear information about food safety on which they can make informed choices. There are significant discrepancies between the U.S. Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (EPA) with regard to acceptable levels of contaminants in fish. These contribute to consumer confusion over the healthfulness of salmon and work against the long-term interest of both the wild and farmed salmon industries.
- **Collect better data about seafood markets and consumers**. Existing data are insufficient to measure or analyze how and why North American fish consumption is changing, or how factors such as price, labeling, certification and origin affect fish consumption, including wild and farmed salmon. Given the importance of fish in North American diets—from not only an economic but a health perspective—the U.S. government and the seafood industry should commit to improved data collection and analysis related to fish consumption and markets. In particular, better data should be collected on wholesale and retail prices in the U.S. for seafood, much as the U.S. Department of Agriculture routinely collects for agricultural products. In addition, routine USDA household surveys on food consumption should focus more on households' seafood consumption, including the species, product forms and quantities of seafood that households are consuming. Only a Federal agency, such as the USDA, has the capability to collect this information consistently over time, across different regions of the U.S. and with appropriate representation of different segments of the U.S. population.
- **Recognize and mitigate environmental impacts of fish production**. Recognizing and addressing environmental impacts (known as "externalities" by economists) is essential for of sustainable resource management. Possible negative environmental impacts of salmon farms include disease transmission from hatcheries and farms to wild stocks, pollution (e.g., from waste feed), competition with wild stocks and the consumption of chemical residues potentially found in salmon by humans or other organisms. Hatchery release programs may have similar effects. All of these potential effects should be recognized and addressed. To reduce potential negative effects of biological interactions between wild salmon and farmed salmon, including disease, pollution and inter-/intra species competition, polices and regulations should be employed that reduce the likelihood of direct interaction between wild and farmed salmon, such as appropriate farm siting and cage construction standards. There should be strict compliance with chemical and antibiotic use protocols.
- **Recognize the role of hatcheries**. Salmon hatcheries account for a significant share of North American "wild" salmon catches, particularly of pink and chum salmon. There are important issues related to the effects of hatcheries on salmon ecosystems, as well as to the economic role of hatcheries in commercial salmon fisheries and markets. These issues should be explicitly recognized in analysis and policy discussions about North American "wild" fisheries.
- **Expand marketing efforts**. Marketing wild salmon as 'wild' has been successful in the U.S. market in 2005, particularly for the higher quality

species — chinook, coho and sockeye – and has contributed to increases in ex-vessel prices paid to fishermen for these species. However, it has had no clear impact on ex-vessel prices for pink and chum salmon — which comprise 66 percent of Alaskan salmon landings. Achieving sustained increases in ex-vessel prices for pink and chum salmon will require expanding demand for the products made from these species (or, alternatively a reduction in supply through changes in management).

- **Recognize that the choices are not between wild and farmed salmon**. It is essential to move away from the simplistic perspective that policy makers and consumers face a choice between wild salmon and farmed salmon. Salmon farming is a major world industry which is here to stay. Wild salmon is incapable of supplying the much larger domestic and world salmon market which has been created by farmed salmon. Natural wild salmon, hatchery salmon, and salmon farming all offer potential economic opportunities and benefits to consumers. All also have inherent risks. The real issues are how to take responsible advantage of the potential economic opportunities and benefits to consumers from both wild and farmed salmon.
- **Work to ensure wild salmon is a competitive product**. A competitive strength of farmed salmon is consistent high quality that can be delivered to the market when the buyer demands it. To improve market conditions for wild fresh or frozen salmon the wild salmon industry must provide buyers with product which meets the higher quality standards established by farmed salmon. For wild salmon to compete effectively with farmed salmon, it is not enough for it to be 'wild.' The fish must also be handled very carefully when caught and processed and delivered where and when the buyer demands it.
- **Take advantage of potential benefits of MSC certification for Alaska wild salmon**. Sustainability, and the traceability proving sustainability provided by a certification program such as the MSC, are becoming increasingly important to many in the seafood market chain in the U.S. and Europe. Wild salmon enjoys potential market advantages as a "sustainable" product. To fully recognize these potential advantages the Alaska salmon industry should seek to make more use of the MSC label, and to develop and promote its importance to buyers and consumers as a measure of sustainability and traceability.

References

Anderson, J.L. 1997. The Growth of Salmon Aquaculture and the Emerging New World Order of the Salmon Industry. in K.L. Pikitch, D Huppert and M. Sissenwine (eds.) *Global Trends: Fisheries Management*. American Fisheries Society. Bethesda, MD. pp. 175-184.

Asche, F., T. Bjørndal, and E.H. Sissener. 2003. Relative productivity development in salmon aquaculture. *Marine Resource Economics* 18:205-210.

Barlow, S.M. 2002. *The World Market Overview of Fish Meal and Fish Oil*, Paper presented to the 2nd Seafood By-Products Conference, Alaska. November.

Delgado, C.L., N. Wada, M.W. Rosengrant, S. Meijer, and M. Ahmed. 2003. *Fish to 2020: Supply and Demand in Changing Global Markets*. International Food Policy Research Institute, Washington, D.C.

Department of Fisheries and Oceans. 2000. Backgrounder: The Future of the Salmonid Enhancement Program. BG-PR-00-08E. March 15, 2000. http://www-comm.pac.dfo-mpo.gc.ca/pages/release/bckgrnd/2000/bg0008_e.htm.

Federal Register, 1998. *Preliminary Ruling on Anti-Dumping Duties'*, 63(223):2664-2671.

Guttormsen, A. 2002. Input factor substitutability in salmon aquaculture. *Marine Resource Economics*. 17:91-102.

Hicks, B. 1995. Canada losing the race—what makes Chile run… *Northern Aquaculture* 11(1):16-19.

Hites, R.A., J.A. Foran, D.O. Carpenter, M.C. Hamilton, B.A. Knuth, and S.J. Schwager. 2004. Global Assessment of Organic Contaminants in Farmed Salmon. *Science* 303:226-229.

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

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

Pacific Fisheries Resource Conservation Council. 2000. "Wild Salmon Policy" and the future of the Salmonid Enhancement Program: The Response of the Pacific Fisheries Resource Conservation Council. June 2000. http://www.fish.bc.ca/html/fish2230.htm

PricewatershouseCoopers, LLP. 2003. *A Competitiveness Survey of the British Columbia Salmon Farming Industry*. Prepared for the Aquaculture Development Branch, Ministry of Agriculture, Food and Fisheries. May.

Reichhardt, T. 2000. Will souped-up salmon sink or swim? *Nature* 406:10-12.

Salmon of the Americas (SOTA). 2004. PCBs and farmed salmon: facts to go with the fiction. http://www.salmonoftheamericas.com/topic_ewg_pcb.html .

Santerre, C. 2004. "Farmed salmon: caught in a numbers game". *Food Technology* 58(2):108.

Tacon, A.G.J.. 1998. Global Trends in Aquaculture and Aquafeed Production 1984-1995, In *International Aquafeed Directory & Buyers' Guide 1998*. pp. 5-37. Uxbridge, United Kingdom.

United States Department of Commerce / National Marine Fisheries Service (2006). U.S. Foreign Trade. Available at http://www.st.nmfs.gov/st1/trade/index.html

United States International Trade Commission (US ITC). 2003. *Modification to the Harmonized Tariff Schedule of the United States to Implement that United States-Chile Free Trade Agreement*, USITC Publication 3652, December.

The Wave News Network, 2004. "Fixing the world's largest salmon hatchery system," April 26.

Wijkström, U.N. and M.B. New. 1989. "Fish for Feed: A Help or a Hindrance to Aquaculture in 2000?" *INFOFISH International* 89(6):48-52.

Willett, W. 2005. "Fish: balancing health risks and benefits," *American Journal of Preventative Medicine* 29(4):320-321.