

A Review of World Salmon Culture

Introduction

World farmed salmon production reached 145,000 metric tons (t) in 1988 and an estimated 217,000 t in 1989. The latter figure is comparable to the U.S. annual salmon catch (about 250,000 t) and is approaching one-third the size of the world wild salmon catch (about 700,000 t). The rapid expansion of farmed salmon supplies in the late 1980's has led to sharp price decreases. Lower prices have forced some farmers out of business, but at the same time, a large number of farmers first began harvesting salmon on a commercial scale as the 1980's ended. Farmed salmon production could exceed 270,000 t in 1990.

Most salmon farmers raise Atlantic salmon, *Salmo salar*, reflecting the fact that farming technology was developed in Europe. The world's largest farmed salmon producer is Norway, accounting for about half of total production in 1988-1989. In early 1990, Norwegian producers for the first time announced plans to freeze significant quantities of salmon for export. The action is intended to protect the huge Norwegian industry by stabilizing fresh salmon prices, but it could also adversely affect frozen salmon exporters in the United States.

Apart from Norway, other European countries have also developed major salmon farming industries.

Important European Community (EC) producers include the United Kingdom (Scotland) and Ireland. Canada, Japan, and Chile have become major producers of Pacific salmon species in recent years. New Zealand and Australia are still in the early stages of development but could become major salmon producers in the 1990's.

Note: This report, IFR-90/30, was prepared by Brian D. McFeeters, Foreign Affairs Assistant, Office of International Affairs, NMFS, NOAA, Silver Spring, MD 20910. Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

Growth

Salmon culture emerged as a major economic activity during the 1980's. At the beginning of the decade, salmon farming was a novel undertaking. World production, almost exclusively from Norway and Japan, amounted to only 7,000 t. The chief difficulties for aquaculturists, as the decade began, were technical. Farmers had to develop profitable methods of raising salmon, while

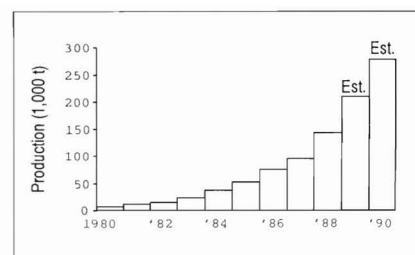


Figure 1.—World farmed salmon production (1,000 t), 1980-90.

facing the danger that disease, predators, or storms could wipe out their entire stock. As the 1980's ended, the situation was considerably different. World production levels had increased 30-fold, reaching an estimated 217,000 t in 1989 (Fig. 1, Tables 1, 2). Norway was still the

Table 1.—World farmed salmon production, 1980-89, with projections for 1990¹.

Nation	Production, live weight (t)										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
EC											
France	30	40	40	40	50	60	60	60	60	60	600
Ireland	21	35	100	257	385	722	1,500	2,232	4,200	7,300	10,000
Spain	0	0	0	0	100	150	150	200	300	450	600
UK	598	1,333	2,136	2,536	3,912	6,921	10,338	12,721	17,951	31,015	35,000
Subtotal	649	1,408	2,276	2,833	4,447	7,853	12,048	15,213	22,511	38,825	46,200
Non-EC Eur.											
Faroe Isl.	0	0	60	105	116	470	1,370	3,500	3,400	8,000	10,000
Finland	0	30	30	30	94	100	100	127	150	170	200
Iceland	0	20	30	50	107	91	123	530	1,233	3,900	8,600
Norway	4,143	8,422	10,266	17,000	25,936	33,796	49,985	56,204	83,700	114,866	150,000
Sweden	0	0	10	15	59	81	160	224	363	500	500
Subtotal	4,143	8,472	10,396	17,200	26,312	34,538	51,738	60,585	88,846	127,436	169,300
N. America											
Canada											
Atlantic	11	21	38	68	222	349	646	1,350	3,100	3,150	3,250
Pacific	157	176	273	128	107	120	400	1,362	6,000	14,500	20,000
Subtotal	168	197	311	196	329	469	1,046	2,712	9,100	17,650	23,250
U.S.											
Atlantic	0	0	0	0	23	68	136	800	1,700	3,200	5,200
Pacific	329	873	691	844	1,225	1,752	1,264	1,700	2,000	2,400	2,500
Subtotal	329	873	691	844	1,248	1,820	1,400	2,500	3,700	5,600	7,700
N. Am. total	497	1,070	1,002	1,040	1,577	2,289	2,446	5,212	12,800	23,250	30,950
Other											
Chile											
Atlantic	0	1	184	94	109	500	897	1,138	2,900	5,308	8,000
Pacific	0	0	0	0	0	0	0	57	200	1,200	4,500
Subtotal	0	1	184	94	109	500	897	1,195	3,100	6,508	12,500
Japan	1,855	1,159	2,122	2,760	5,049	6,990	7,533	12,177	16,400	18,600	20,000
New Zealand	0	2	5	10	10	250	500	1,000	1,250	2,000	3,000
Subtotal	1,855	1,162	2,311	2,864	5,168	7,740	8,930	14,372	20,750	27,108	35,500
Grand total	7,144	12,112	15,985	23,937	37,504	52,420	75,162	95,382	144,907	216,619	281,950

¹Note: Excludes data for Australia, with Atlantic salmon production of 380 t in 1988-89 and a projected 1989-90 production of 2,000 t.

largest producer, accounting for over half of the total, but several other nations had developed sizable salmon farming industries (Fig. 2). Another group of nations had begun to farm salmon on a commercial scale in the mid-1980's and was poised to rapidly expand production as the decade ended. Many of the earlier technical difficulties of salmon farming had been overcome through experience and extensive research.

Impressive advances in the production of farmed salmon in the late 1980's have

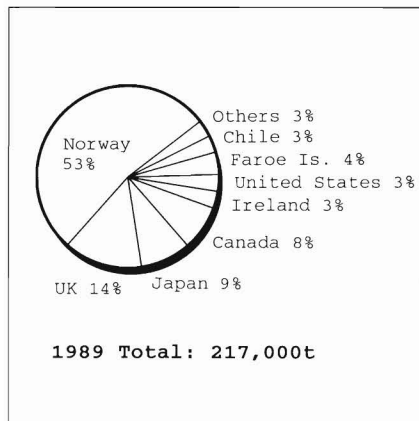


Figure 2.—Farmed salmon production by major producing nations, 1989 (est.).

created new difficulties. Early in the decade, farmed salmon was a rarity on world markets, priced as a luxury food. By 1989, however, producer prices for farmed salmon had fallen sharply as exporters placed ever-increasing quantities on the market. For large producing nations, such as Norway, the decline in salmon prices disturbed what had become a major sector of the fishing industry. For salmon farmers in other countries, many of them still paying high start-up costs, falling prices posed a more serious threat. As the 1990's began, the world's salmon farming industry faced great uncertainty: Neither prices nor production levels had stabilized.

Recent Trends

Prices

Fresh salmon prices declined gradually during most of the 1980's as farmed salmon supplies increased. In the UK, for example, fresh salmon prices declined by 30 percent from 1980 to 1987 (Shaw, 1989:28). During 1988-89 when supplies of farmed salmon surged, steadily declining prices became a major concern for salmon producers. Between January 1988 and December 1989, Norwegian farmed salmon prices fell by 40 percent

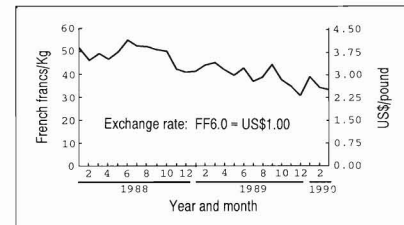


Figure 3.—Average prices (Rungis, France) for Norwegian farmed salmon, 1988-90.

(from about \$4.00/lb to \$2.30/lb) in Europe's largest wholesale market near Paris (Fig. 3). Prices recovered somewhat in early 1990, but remained well below \$3.00/lb. Lower prices have severely reduced profit margins: One 1987 study estimated farmed salmon production costs in Europe at \$2.00-\$2.50/lb (DPA Group, Inc., 1989).

Producer Reaction

In the face of falling prices, salmon farmers appear unwilling to allow market forces to determine the future of their industry. EC producers have alleged that Norwegian salmon farmers are selling at below cost, or "dumping," fresh salmon in the EC market. Norwegians dispute this charge. Even so, Norwegian producers, whose exports have a large impact on fresh salmon markets worldwide, limited the expansion of their fresh salmon exports in 1989, and they indicated that they would limit fresh salmon supplies in 1990 as well.

Technical Issues

Although many technical issues plaguing early salmon farmers have been resolved, others have grown more acute. To compete in world markets, many farmers opted for intensive farming methods, raising salmon under high-density conditions. While these methods permit increased yields, they also place the fish under stress, making them vulnerable to a variety of pathogens, and increasing the chances that one diseased fish will infect others. Unduly stressed salmon have even suffered heart attacks. Researchers have developed many effective vaccines and medications as well as other methods to treat salmon raised under high-density conditions. While

Table 2.—World production of farmed Atlantic and Pacific salmon, by species group, 1980-89 with projections for 1990¹.

Salmon type and nation	Production, live weight (t)										
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Atlantic salmon											
Canada, Atl.	11	21	38	68	222	349	646	1,350	3,100	3,150	3,250
Chile	0	1	184	94	109	500	897	1,138	2,900	5,308	8,000
Faroe Isl.	0	0	60	105	116	470	1,370	3,500	3,400	8,000	10,000
Finland	0	30	30	30	94	100	100	127	150	170	200
France	30	40	40	40	50	60	60	60	60	60	600
Iceland	0	20	30	50	107	91	123	530	1,233	3,900	8,600
Ireland	21	35	100	257	385	722	1,500	2,232	4,200	7,300	10,000
Norway	4,143	8,422	10,266	17,000	25,936	33,796	49,985	56,204	83,700	114,866	150,000
Sweden	0	0	10	15	59	81	160	224	363	500	500
UK	598	1,333	2,136	2,536	3,912	6,921	10,338	12,721	17,951	31,015	35,000
U.S.	0	0	0	0	23	68	136	800	1,700	3,200	5,200
Subtotal	4,803	9,902	12,894	20,195	31,013	43,158	65,315	78,886	118,757	177,469	231,350
Pacific salmon											
Canada, Pac.	157	176	273	128	107	120	400	1,362	6,000	14,500	20,000
Chile	0	0	0	0	0	0	0	57	200	1,200	4,500
Japan	1,855	1,159	2,122	2,760	5,049	6,990	7,533	12,177	16,400	18,600	20,000
New Zealand	0	2	5	10	10	250	500	1,000	1,250	2,000	3,000
Spain	0	0	0	0	100	150	150	200	300	450	600
U.S.	329	873	691	844	1,225	1,752	1,264	1,700	2,000	2,400	2,500
Subtotal	2,341	2,210	3,091	3,742	6,491	9,262	9,847	16,496	28,150	39,150	50,600
Grand total	7,144	12,112	15,985	23,937	37,504	52,420	75,162	95,382	144,907	216,619	281,950

¹Note: Excludes data for Australia Atlantic salmon production (1989-90 est. 2,000 t).

these measures are effective, there is some concern among consumers—and therefore among farmers also—about the use of such medical additives in the production of salmon.

Smolts

Concern over the spread of disease has also led many nations to reduce or curtail their imports of salmon eggs and smolts (juvenile salmon). In Iceland, which entered the salmon industry mainly as an exporter of smolts, the disappearance of foreign markets has prompted an expansion of domestic salmon farming. In other nations, the governments operate smolt hatcheries to assist farmers. Lately, however, there is a trend toward vertical integration of salmon farms among the larger producers. Some salmon farmers in Norway, Scotland, and Canada now breed salmon in their own hatcheries.

Technological and Environmental Issues

The technology of salmon farming is becoming sophisticated, helping farmers to remain competitive even when they are forced to raise salmon under difficult offshore conditions. Movable floating sea-cages, automated feeding equipment, and waste filtering systems are increasingly common. Norway has led the way in developing technology, but smaller producing countries have also introduced innovations. In France, aquaculturists are attempting to raise salmon in a converted oil tanker.

Environmental considerations are closely connected with the technical issues involved in salmon farming. As salmon farms have expanded, becoming an industry rather than a novelty, they have sparked opposition from groups concerned with coastal pollution, the purity of wild salmon stocks, and other ecological issues. Local fishermen sometimes object to the waste excreted by farmed salmon. In Ireland, environmental groups have objected to the installation of salmon farms on scenic stretches of coast which are important for tourism. Because of opposition to the use of coastal sites, many salmon farms are being installed offshore.

Ranching

The term “salmon ranching” refers to the practice of releasing juvenile salmon into the ocean for later recapture. While less important than farming as a source of cultured salmon, ranching has recently expanded in several countries. Salmon ranching is not covered in detail in this report, but it is an activity with substantial potential in the 1990's. There are two types of salmon ranching. In the first, widely practiced in Japan, the juvenile salmon released into the ocean are later caught by coastal fishermen. This method, which adds to the existing wild salmon populations, accounts for most of Japan's 150,000 t annual catch of chum salmon (Tashiro, 1988). Other nations, including Iceland, have also engaged in this kind of salmon ranching. This second type of ranching is more closely related to salmon farming. Instead of allowing the salmon to be caught at sea, ranchers rely on the natural tendency of salmon to return to their river (or, in this case, coastal ranch site) of origin. Though ranchers have had mixed success in actually recapturing mature salmon, this method appears to have two potential advantages over conventional farming: Production costs could be quite low, since salmon are raised at sea; ranchers may be able to promote their product as being indistinguishable from pure wild salmon.

Species Discussed and U.S. Salmon Farming

The term “Atlantic salmon” used in this report refers to *Salmo salar*, the species raised throughout Europe, with few exceptions. The term “Pacific salmon” refers to a group of related species: Coho or silver salmon, *Oncorhynchus kisutch*; chinook or king salmon, *O. tshawytscha*; cherry salmon, *O. masou*; sockeye or red salmon, *O. nerka*, and chum salmon, *O. keta*. The species produced in a particular country is (are) identified in the text.

Salmon farming in the United States, not covered in this report, yielded an estimated 5,600 t of salmon in 1989, making the United States the eighth largest cultured salmon producer (Table 1). Farmers in the United States produce



both Atlantic and Pacific (mostly chum) salmon.

Norway

Norway produces Atlantic salmon exclusively. In 1988, production was 83,700 t, while 1989 production of the species was estimated at 115,000 t.

Production

Norway dominates the world farmed salmon industry. In 1989, it produced over half of the world's farmed Atlantic salmon. As the world's pioneer in salmon culture, Norway has enjoyed a spectacular record of success. All sectors within the industry—smolt producers, feed manufacturers, salmon farmers, and salmon exporters—have shared in a remarkable era of growth (Fig. 4). This growth has not been achieved without difficulties, however. The sharp Norwegian production increases in recent years—an estimated 115,000 t in 1989 compared with 83,700 t in 1988 and 56,000 t in 1987—

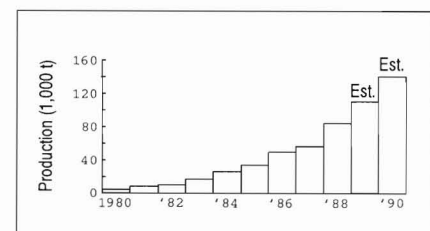


Figure 4.—Norwegian farmed Atlantic salmon production (live weight), 1980-90.

have disrupted salmon markets throughout the world. The quantities of salmon reaching commercial size have become difficult for even the skillful Norwegian exporters to market.

As production increased, salmon prices declined substantially in 1989 (Fig. 3), impairing the profitability of the industry. By late 1989, prices received by Norwegian farmers for large Norwegian salmon had fallen to about \$4.90/kg (\$2.22/lb), less than half of their 1987 levels. Norwegian salmon farmers were predicting operating losses of as much as \$29 million for 1989.

Norway's production of farmed salmon could have been higher in 1989. Some industry representatives had predicted harvests as high as 150,000 t. However, when the rapid increase in world supplies of farmed salmon caused prices to decline, Norwegian salmon farmers began to scale back their production estimates. To prevent further price erosion, farmers intentionally limited harvests to 115,000 t—still a record level—instead of the estimated 140,000 t of salmon that were approaching market size.

This self-imposed restraint on 1989 production means that Norwegian farmers carried over substantial "inventories" of penned harvestable salmon, raising the possibility that additional supplies of fresh Norwegian salmon would be brought to market in early 1990. Recognizing the continuing threat to profits, the Norwegian salmon farming industry took strong action to shore up prices in the short term and to limit supplies of fresh salmon in the long term. The Norwegian Fish Farmers Sales Organization (NFFSO) has announced plans to buy and freeze 20,000-40,000 t of salmon. The Organization plans to borrow \$200 million from private banks to finance the freezing plan, and will impose a levy of \$0.75/kg on all exports of fresh salmon in 1990 to pay off the loan. Odd Ustad, director of the NFFSO, stated that the combination of the freezing plan and the tax on exports should keep 1990 prices to producers of fresh salmon at about \$6.30/kg (\$2.86/lb). This action, intended to protect prices in the fresh salmon market, will have an important indirect result: It will significantly increase Norway's in-

Table 3.—Norwegian exports of farmed salmon by country of destination, quantity, and values, 1987-88.

Country of destination	1987		1988	
	Quantity \$ in 1,000 t	Value million dollars	Quantity \$ in 1,000 t	Value in million dollars
France	11.3	83.6	18.7	130.1
Denmark	7.7	51.8	14.2	92.1
U.S.	7.8	60.3	9.9	76.5
F.R.G.	4.7	37.9	7.5	56.6
Japan	1.3	10.2	3.0	23.4
Other	9.2	69.8	14.8	107.4
Total	42.0	313.6	68.1	486.1

volvement in the frozen salmon market, an area in which Norway has played only a limited role in the past.

Farms

There have been about 600 salmon farms operating in Norway since the mid-1980's. Although the number of farms has not increased significantly, potential farming capacity expanded in 1988, when the Norwegian Government permitted fish farmers to increase the size of individual farms from 8,000 m³ to 12,000 m³. Smolt production reached a peak of 75 million in 1988, but declined to an estimated 62 million in 1989.

Exports

Norway's exports of farmed salmon have increased tenfold over the past decade, from \$43 million in 1979 to \$486 million in 1988. The EC is the principal market for Norwegian salmon exports (Table 3). In 1988, over 60 percent of such exports were sold to EC nations, about 15 percent went to the United States, and 5 percent to Japan. In 1988, the three largest salmon exporters in Norway were the Skaarfish (sales of over \$100 million), Domstein, and Hallvard Leroy companies.

According to preliminary reports, Norway exported an estimated 100,000 t of salmon, worth \$585 million, in 1989. As in previous years, the largest markets for farmed salmon exports were in the EC, principally France, Denmark, and the Federal Republic of Germany. Exports to the United States increased in quantity to 11,400 t, but declined in value to \$67 million. Shipments to Japan increased to almost 4,700 t.

Norway's increasing salmon exports to the EC have become controversial. During 1989, Scottish and Irish salmon farmers alleged that Norwegians were dumping under-priced salmon in the EC market, thereby threatening producers in other countries. In February 1990, the European Commission announced that it would investigate the charges. The EC has never before investigated alleged dumping of a food product, and the criteria for such an investigation may be difficult to establish. Norwegian salmon exporters face similar protests in the United States. U.S. producers of Atlantic salmon filed anti-dumping and countervailing duty complaints against Norway in February 1990.

As their European and U.S. markets have become somewhat problematic, Norwegian salmon farmers have turned increasing attention to the huge Japanese market for salmon, as indicated by the growing share of fresh salmon exports shipped to Japan in 1989. In 1990, Norway may also attempt to sell a significant portion of its frozen salmon production—estimated at 40,000 t—to Japanese importers. However, the U.S. Embassy in Tokyo reported in early 1990 that the Japanese salmon market was oversupplied and that Japanese importers would not accept large quantities of Norwegian frozen salmon unless prices declined significantly. Such a price decline would probably also affect U.S. exports of frozen salmon to Japan.

Outlook

Norwegian salmon farmers faced an uncertain market during late 1989 and early 1990, as evidenced by their decision to delay the harvest of some salmon and to freeze excess quantities as they are harvested. (It is not known whether Norway will continue to freeze salmon in future years.) This uncertainty means that forecasts of Norway's farmed salmon production for 1990 and beyond are extremely tentative. The NFFSO has asked salmon farmers to limit production of both salmon and smolts. Though a 140,000 t salmon harvest is currently being forecast for 1990, market conditions—rather than production capacity—may dictate lower production levels.

Continuing annual increases in Norway's farmed salmon production are no longer assured.

Faroe Islands

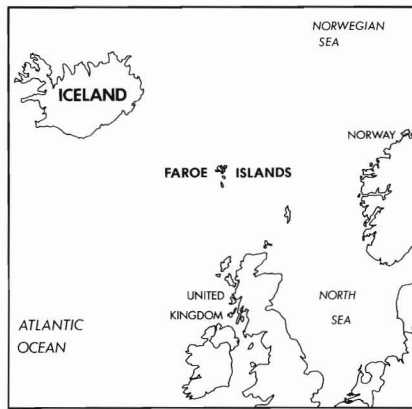
Salmon culture in the Faroe Islands is also limited to the Atlantic salmon. In 1988, 3,400 t were harvested, and the figures more than doubled in 1989 to an estimated 8,000 t.

Production

The Faroe Islands, a self-governing province of the Kingdom of Denmark, has rapidly increased its production of farmed salmon since the mid-1980's (Fig. 5). Production first reached 1,000 t in 1986. Harvests have increased since then, but Faroese salmon farmers have also faced setbacks. Losses from fish diseases and algae blooms hurt 1988 production, which reached only 3,400 t instead of the expected 4,200 t. In addition, many salmon farms were destroyed in late 1988 when severe storms—the worst in 100 years—raged through the Islands, with winds of up to 150 miles per hour. Despite these difficulties, production of farmed Atlantic salmon recovered in 1989 and reached an estimated 8,000 t, more than double the 1988 level.

Salmon farming has taken on increasing importance in the Faroe Islands—where catching and processing fish is the mainstay of the economy—because of the downturn in wild fishery catches in recent years. Faroese fishermen invested heavily in high-seas trawlers, but have lost their access to traditional distant-water fishing areas off Greenland and Norway.

The Faroese Home-Rule Government supported the start of the salmon farming industry by providing technical assis-



tance and investment loans to fish farmers. Besides providing essential financial support, the Government has also regulated the industry in several ways. The importation of smolts is prohibited in order to protect Faroese salmon from diseases and the number of farms is limited in order to protect the environment.

The Government's prohibition on the import of salmon smolts at first limited the growth of the Faroese salmon farming industry; all smolts had to come from the Government-run hatchery. Salmon farming expanded rapidly after 1984, when the new Government allowed individual farmers to operate their own hatcheries. By 1987, smolt production was estimated at 3 million fish per year.

Farms

There were about 50 salmon farms in the Faroe Islands in 1989, producing an annual average of 160 t of salmon. Most salmon farmers make use of sea-cages located in narrow fjords, but the Government has encouraged farmers to use off-

shore cages because of environmental concerns. There were 17 offshore cages operating in 1989.

Exports

The bulk of the farmed salmon produced in the Faroe Islands is exported. In 1987 (the latest year for which export data are available), the Islands exported 82 percent of the cultured salmon produced. The bulk of these exports (95 percent) were shipped to the EC, especially to Denmark (Table 4). The United States purchased \$1 million worth of farmed salmon from the Faroe Islands in 1987, but only \$236,000 worth in 1989.

Outlook

The conservative Faroe Islands Government elected in 1989 entered office facing a \$1 billion debt. This sum, inherited from former governments that spent heavily for social welfare, makes increased aid to salmon farmers unlikely. Salmon farming is expected to continue expanding at a moderate pace—1990 production was forecast at 10,000 t.

Iceland

Production

Salmon farming in Iceland first reached commercial scale in 1987, when farmers produced 530 t. Since then, production has more than doubled each year, to 1,200 t in 1988, and to an estimated 3,900 t in 1989 (Fig. 6). Although Iceland does not rival either Norway or the UK as a producer of market-sized salmon, the nation has played an important role in the development of the salmon aquaculture industry as an exporter of salmon smolts. The island's geothermal resources were

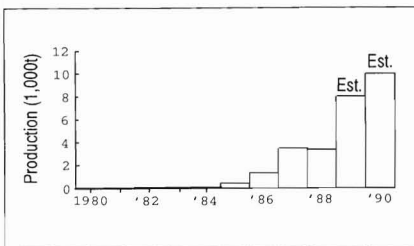


Figure 5.—Faroe Islands' farmed Atlantic salmon production (live weight), 1980-90.

Table 4.—Faroe Islands exports of farmed salmon by country of destination in amount (t) and value (\$1,000), 1987.

Destination	1987		Destination	1987	
	Amt.	Value		Amt.	Value
Denmark	1,061	7,300	UK	45	300
France	598	4,700	Belg.-		
F.R.G.	542	4,400	Luxem.	42	400
Spain	322	2,600	Norway	32	300
U.S.	112	1,000	Others	10	100
Italy	68	400			
Netherl.	47	300	Total	2,880	21,800

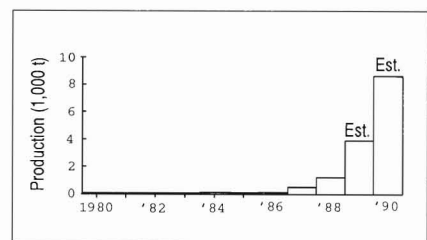


Figure 6.—Icelandic farmed Atlantic salmon production (live weight), 1980-90.

harnessed to provide temperature-controlled water for over 50 hatcheries. Production of smolts for several years exceeded the farming capacity in Iceland, so millions of smolts were exported in the mid-1980's, mostly to Norway and Ireland.

In recent years, Iceland has reduced its exports of smolts because foreign markets have largely evaporated, but it has continued to increase smolt production to supply its growing domestic industry. In both 1988 and 1989, over 10 million smolts were raised (compared to 4 million in 1987), none of which were exported, indicating that Icelandic salmon production may exceed 8,000 t in 1990.

Foreign investment and Government assistance have played important roles in the development of Iceland's salmon farming industry. Norwegian companies had invested over \$45 million in Icelandic salmon culture and equipment as of 1987, the latest year for which such data were available. This amount was one-third of the total investment in the salmon farming industry. The Icelandic Government has provided additional impetus to salmon farmers by offering low-cost financing. During 1989, as Icelandic salmon farmers began feeling the impact of lower world salmon prices, the Icelandic Prime Minister proposed a Government initiative to address financial problems in the aquaculture sector.

Farms

About 60 salmon farms operated in Iceland in 1989 and about 20 salmon ranching enterprises. In recent years, the number of fish farms has not increased rapidly, but culturists have begun to make greater use of their farms' capacity. They have placed the bulk of the smolts in sea-cages, similar to those used by other nations. Because Iceland's bays and inlets are not as well protected as those in Norway or Scotland, some Icelandic farmers have installed land-based farms.

Salmon farmers in Iceland were hard hit in 1989 by the decline of their smolt export markets and the decrease in world salmon prices. At least 10 farms filed for bankruptcy late in the year. One of the failed companies was Islandlax, a joint venture between Iceland's Samband co-

operative association and Norway's Nor-aqua company. The company's owners intended to supply 500,000-700,000 smolts to salmon farms in Norway, but those farms were already fully supplied by Norwegian hatcheries. Because of the difficulty in obtaining credit in Iceland, Islandlax was unable to finance the raising of salmon to market size, and went bankrupt with debts of \$18 million.

Despite such setbacks, many Icelandic farmers are successfully making the transition from production of smolts to production of market-sized salmon. Icelandic salmon farmers have emphasized strict standards in their industry, seeking to present their fish on world markets as unsurpassed in quality and free of all chemical additives. Salmon ranching is particularly popular in this context, since it allows farmers to harvest salmon which have matured in the pristine waters surrounding Iceland. Salmon ranching is expected to yield 1,000 t of salmon per year as of the mid-1990's.

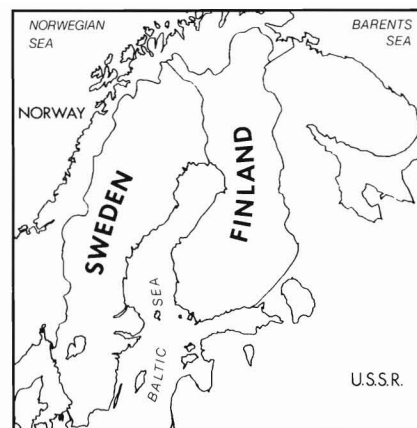
Icelandic farmers have benefited in the past from the technical experience brought in by foreign investors, particularly from Norway, but have lately begun to develop their own technical base. In 1986, the first class of aquaculturists was graduated from Iceland's Agricultural College, and was reported to be in great demand among Icelandic salmon farmers.

Exports

In 1988, Iceland exported 75 percent of its farmed salmon production (Table 5). Exports to the United States, Iceland's largest market for farmed salmon, benefit from air transport links which allow salmon harvested in the morning to be on

Table 5.—Iceland's exports of farmed salmon by country of destination in amount (t) and value (\$1,000), 1988.

Desti- nation	1988		Desti- nation	1988	
	Amt.	Value		Amt.	Value
United States	370.5	2,767	Denmark	8.1	52
France	232.9	1,344	Belgium	2.0	11
Switzerl.	59.2	531	Spain	0.3	2
Japan	53.5	452	Hong Kong	0.2	2
F.R.G.	32.6	241	Italy	0.1	1
UK	32.0	186	Sweden	0.1	1
Netherl.	27.8	182	Total	819.4	5,772



sale in New York by the next morning. Iceland also flies fresh salmon to Europe, where the largest market is France, and has recently added air transport service to Japan. In 1989, preliminary estimates indicated that Iceland exported between 1,500 and 2,000 t of salmon, thus doubling the quantity of its 1988 exports.

Outlook

As of early 1989, sources in Iceland indicated that production of farmed salmon would continue to increase at a rapid rate, doubling from 3,900 t in 1989 to over 8,000 t in 1990. The rash of salmon farm bankruptcies in late 1989 may slow the production increase somewhat.

Sweden and Finland

Sweden and Finland both farm the Atlantic salmon, but at relatively low levels. Swedish farms produced 363 and 600 t (est.) in 1988 and 1989, respectively, while Finland harvests for the same years were just 150 and 170 t (est.).

Swedish Production

Swedish salmon farming contrasts sharply with salmon culture in Norway, where salmon farming is a major industry. There are few salmon farms in Sweden (about 15 in 1987); most are small family enterprises on the east coast. About 2 million salmon smolts are raised in Swedish hatcheries each year, but most are released into rivers for stocking purposes rather than raised by farmers. Swedish fishermen catch about 1,000 t of wild salmon in the Baltic each year,

and the Government is more concerned about maintaining wild stock levels than about increasing salmon farming. Salmon farms receive no significant Government aid.

Although salmon farming is not a priority in Sweden, several farmers have introduced innovative production methods. In 1986, farmers tested a "Semi-Submersible Offshore Farm" in the North Sea. The capability to produce salmon offshore may be important to the future of aquaculture in Sweden, where concern for protection of coastal areas is strong. Other innovations involve the species being farmed. One Swedish company is successfully producing Arctic char, *Salvelinus alpinus*, which is considered more difficult to raise and potentially more profitable than other members of the salmon family.

Finnish Production

Finland's production of farmed salmon is small, hardly reaching commercial levels. Finnish salmon farmers began by producing smolts for export to rapidly expanding Norwegian salmon farms. While its inland waters are ideal for raising smolts, raising adult salmon in Finland has been more difficult because its coastal waters are quite cold. The Gulfstream, which warms the coastal waters of both Scotland and Norway, does not reach Finland. Another difficulty for salmon farmers is the low salinity of the Baltic Sea.

In recent years, as exports of salmon smolts to Norway declined—especially when Norway temporarily suspended all smolt imports for fear of disease—farmers have attempted to develop their own salmon farming capacity, despite tech-



nical difficulties. Finland has also joined Sweden in releasing salmon smolts into the Baltic in an effort to rebuild wild stocks. In 1986, scientists at the State Central Fish Culture Station in eastern Finland began work on a salmon ranching project in which released smolts would return to the hatchery. Finnish farmers have also successfully attempted to raise chum salmon and Arctic char.

UK: Scotland

Production

Scotland's production of farmed Atlantic salmon—second only to Norway's—has increased steadily since the mid-1980's (Fig. 7). Salmon production expanded from about 18,000 t in 1988 to an estimated 31,000 t in 1989 and was forecast to exceed 43,000 t in 1990. Fish farmers in Scotland have had considerable success overcoming the many technical problems involved in commercial salmon farming. The Scottish industry, however, faces marketing difficulties because of the tremendous growth in farmed salmon supplies to the EC during 1988-89. As salmon exports from Norway have increased, prices throughout the EC have fallen. At two of the largest wholesale fishery markets in Europe (Billingsgate in London and Rungis near Paris) salmon prices fell below those of cod in mid-1989.

For Scottish salmon farmers, whose product has enjoyed a reputation for high quality and high price, the prospect of

lower prices in both domestic and foreign markets is discouraging, but not catastrophic. Although several farms closed in 1989, others opened or expanded. Farmers have continued to introduce more sophisticated production methods. Smolts are vaccinated against diseases and are often airlifted to farms by helicopter.

Instead of introducing measures to limit the expansion of salmon production, as Norwegian farmers have begun to do recently, Scottish farmers seem to be betting that the market for their salmon will continue to expand. Andrew Gray, the marketing director for the Scottish Salmon Board, states that production will be allowed to expand to 55,000-65,000 t by 1992. Unless world markets expand more than expected, he says, production will not be increased beyond that level.

Farms

Most UK salmon farms are located in northwest Scotland, where bays and islands provide sheltered sites. There are also farms on the east coast and on the Shetland Islands. In 1988, there were 153 companies operating 258 farms, compared to 126 companies and 196 farms in 1987. The majority of these farms used sea-cages, though 14 sites used shore-based tanks or raceways. Of the almost 18,000 t of salmon harvested in 1988, 12,000 t were from smolts received in 1987 and 6,000 t from 1986 smolts. The 22.5 million smolts produced in 1988 were supplied by 90 companies operating 176 sites. Smolt production was expected to reach 28.7 million in 1989, and 33.6 million in 1990.

Many early investments in Scottish aquaculture were made by the Dutch-owned Unilever company, through its Marine Harvest subsidiary. As early as 1986, Marine Harvest had invested \$20 million in Scotland, operating 3 salmon hatcheries, 4 freshwater smolt farms, and 18 salmon culturing farms. By 1988, Marine Harvest produced an estimated 5,500 t of farmed salmon. In 1989, the company expanded its processing plant and expected to harvest 8,000 t of salmon, or about 25 percent of the entire UK production.

Farmers in the Shetland Islands pro-

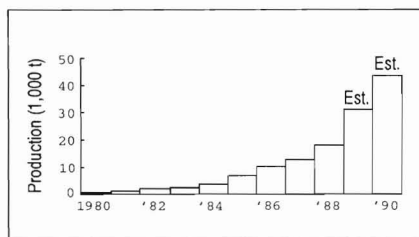


Figure 7.—United Kingdom farmed Atlantic salmon production (live weight), 1980-90.

duced a record 8,000 t of salmon in 1989, a 74 percent increase over 1988. The salmon harvest was valued at an estimated \$44 million, \$11 million more than the value of the entire 1989 pelagic and groundfish catch off the Shetlands. Even so, salmon farmers in the Shetlands felt the effects of lower prices on European markets. The value of their record harvest increased only by one-third over 1988 levels.

Exports

Most salmon produced in the UK is consumed domestically. In 1988, UK salmon farmers exported 36 percent of their harvest, with a value of \$52 million (Table 6). France was the largest export market, followed by the Netherlands. The United States imported \$4 million worth of farmed salmon from the UK in 1988. Importers in the United States reportedly hold Scottish salmon in high regard, but have recently begun to resist the higher prices that UK exporters charge. According to some U.S. importers, UK exporters still have to adjust to lower world salmon prices.

In 1989, salmon farmers in the UK increased their exports significantly when production increased by 14,000 t. However, the even larger 1989 production increase in Norway (about 26,000 t) boosted supplies of salmon in the EC market. Prices fell sharply. As discussed previously for Norway, Scottish salmon farmers helped persuade the EC Commission to investigate alleged dumping by Norwegian salmon exporters.

Outlook

The rapid increase in Scottish farmed

salmon production in recent years has forced farmers to reevaluate their marketing strategy. According to William Crowe, of the Scottish Salmon Growers Association, Scottish farmers have decided to commit themselves to mass production of increasing quantities of salmon for larger markets, instead of continuing to promote their product as the hand-crafted "Rolls Royce" of farmed salmon. To market their increased output, Scottish salmon farmers plan to enlarge their overseas markets in the United States and in Japan.

Ireland

Production

Irish production of farmed salmon has increased markedly each year since the mid-1980's and is expected to reach 10,000 t in 1990 (Fig. 8). Production was 4,200 t in 1988 and an estimated 7,300 t in 1989. The Irish Salmon Growers Association is developing a two-part strategy for its expanding industry: 1) A quality assurance program under which each harvested salmon will carry a special gill tag indicating that it has been inspected and 2) a marketing plan targeted at the United States and Japan. Salmon farms in Ireland received \$5 million in EC aid in 1988. Assistance is also provided by the Government's Irish Sea Fisheries Board and Udaras Na Gaeltachta—the latter offers aid to Gaelic speaking areas of Ireland. In 1988, a disease called infectious pancreatic necrosis infected Irish farmed salmon. Farmers estimated that 25 percent of their harvest was lost that year because of the disease. The disease was not a problem in 1989.

Table 6.—United Kingdom exports of farmed salmon by country of destination, 1988.

Destination	1988	
	Quantity (t)	Value (\$1,000)
France	4,281.0	31,757
Netherlands	648.0	5,889
United States	341.0	4,024
Other	1,237.0	10,343
Total	6,507.0	52,013

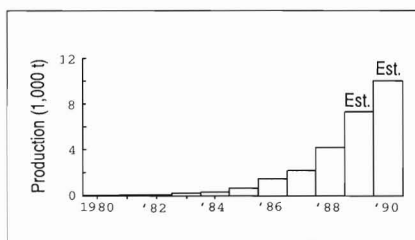


Figure 8.—Ireland's farmed Atlantic salmon production (live weight), 1980-90.

Farms

Only 21 salmon farms were operating in Ireland in 1988, but interest in salmon farming runs high. The Irish Department of the Marine had over 600 aquaculture applications under review in 1989. However, after several years of rapid expansion, salmon farming in Ireland is facing growing resistance from conservationists, representatives of the tourist industry, and recreational fishermen, all of whom oppose the use of picturesque coastal sites for salmon farms and hatcheries.

Because of this resistance, some salmon farms are moving offshore. In 1983, the Irish farmers purchased their first Bridgestone Hi-Seas Cage, manufactured in Japan. By 1989, Irish culturists were operating 28 such cages, becoming the world's largest user. In October 1989, Ireland inaugurated an ambitious 25,000 m³ floating salmon farm, said to be able to produce 400 t of salmon per year.

In 1989, there were 25 Irish companies raising smolts at 32 sites, producing an estimated 9.7 million smolts. This was a significant increase from the 6.9 million smolts raised in 1988. Government licenses are required for freshwater hatcheries, and Government grants are available to finance as much as 65 percent of capital costs.

Exports

Irish farmers exported 2,300 t of salmon, worth over \$16 million, in 1988 (Table 7). France was the largest im-

Table 7.—Ireland's exports of farmed salmon by country of destination, 1987-88.

Destination	1987		1988	
	Quantity (1,000 t)	Value (\$1,000)	Quantity (1,000 t)	Value (\$1,000)
France	1,124	7,206	1,610	10,927
U.S.A.	41	411	267	2,345
UK	365	2,238	185	1,238
Netherl.	27	218	128	1,053
Belg.-Luxem.	63	519	55	433
Spain	75	552	46	316
Japan	17	181	21	141
F.R.G.	9	73	4	52
Switzerl.	2	22	2	12
Denmark	0	0	1	6
Others	10	90	0	2
Total	1,733	11,510	2,319	16,525



porter of Irish salmon, both because of its relative proximity to Ireland and because French consumers prefer the small (1-2 kg) salmon produced in Ireland. Other EC nations accounted for most of Ireland's exports of farmed salmon, but the United States also imported significant quantities, increasing its imports from 40 t in 1987 to almost 270 t in 1988.

Outlook

Irish salmon farmers intend to produce 30,000 t of farmed salmon per year by 1995, but some observers in Ireland are questioning that goal. Decreasing world prices for farmed salmon are a long-term concern. Despite the glut of Norwegian farmed salmon on the market, the Irish Salmon Growers Association maintains that the industry can afford to continue its rapid expansion if it focuses on the large markets in the United States and Japan.

France

French salmon farmers produce varied amounts of both Atlantic and Pacific

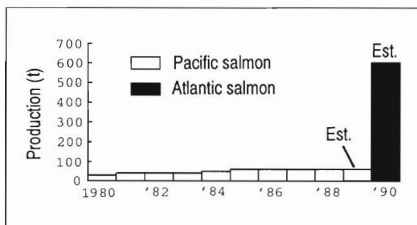


Figure 9.—French farmed salmon production (live weight), 1980-90.

salmon. Production in 1988 was just 60 t but for 1989 it was estimated to be 600 t.

Production

French aquaculturists have emphasized shellfish production (oysters and mussels). Even though it is one of the world's largest salmon importers, France has made no overwhelming effort to become self-sufficient in salmon production, depending instead on imports from North America, and more recently, from Norway and Scotland. In recent years, farmers in Brittany (northwest France) have succeeded in raising trout on a commercial scale, producing about 500 t per year. Pacific coho salmon have been produced at some of the same farms, but on a much smaller scale (Fig. 9). Farmers who have attempted to raise salmon in French waters have reported low survival rates during the summer months when water temperatures rise. Scientists at the National Institute for Agronomy Research (INRA) and the Institut Français pour la Recherche et l'Exploitation de la Mer (IFREMER) are currently investigating the technical aspects of salmon farming in warmer waters, but there is no indication that France will become a major producer of salmon in the foreseeable future.

Farms

The first French farm dedicated exclusively to Atlantic salmon production began operation in mid-1989, when about 230,000 smolts were delivered from Norway to the barge *Ile Sous le Vent*, a converted Portuguese oil tanker. The vessel is the first known conversion of a tanker for use as a salmon farm. The 116 m long floating farm, equipped with four 4,000 m³ holds, is anchored about 5 km off the north coast of Brittany in Morlaix Bay. Capacity is limited to 500,000 smolts which should yield about 600 t of salmon in 1990. Future harvests from this \$10 million farm are expected to reach 750 t per year. Another converted oil tanker was due to arrive in the Bay in 1990, bringing potential production levels to 1,500 t annually. However, local environmental groups are seeking to limit the expansion of this salmon farming project.



Other French firms are interested in raising farmed salmon as well. In Plouguerneau, the Fermor company plans to establish a salmon farm that will produce 300 t of salmon annually. The Bouygues group plans to establish a 1,000-2,000 t annual capacity farm off Camaret. Six 30 m diameter cages will be linked to a central tower. If the sea gets too rough, the cages will be lowered to a depth of 20 m. Overseas, the French Regional Association for the Development of Aquaculture (ARDA) has helped establish Atlantic salmon farms on the islands of St. Pierre and Miquelon, off Canada.

Spain

Production

Spanish Atlantic salmon farming exists only on a very small scale (Fig. 10). In contrast to its large trout farming industry, Spain's salmon farms only produced about 300-500 t per year during 1988-89. As in France, salmon farmers

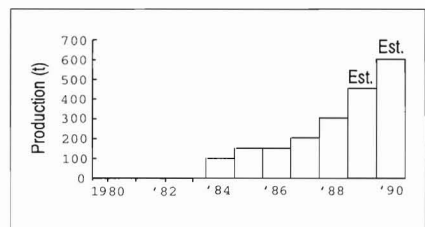
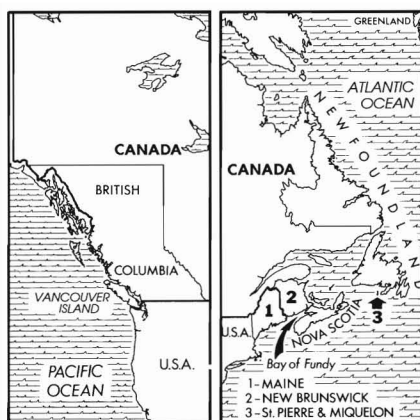


Figure 10.—Spanish farmed Atlantic salmon production (live weight), 1980-90.



have faced difficulties because of Spain's relatively warm waters.

Norwegian investors announced plans to establish several salmon farms in northern Spain in 1988. The Norwegians believed that technical difficulties could be overcome, and were interested in gaining access to Spain's growing salmon market. Current information on these farms was not available, but the Spanish market for salmon and trout is indeed expanding. In 1988, salmon and trout imports (aggregated in Spanish trade statistics) increased to 7,300 t from 4,300 t in 1987.

Canada

Canada farms both Atlantic and Pacific salmon, including several species of the latter. Total output in 1988 was 9,100 t, while 1989 harvests were projected to hit 16,700 t.

Production

Canadian salmon farmers forecast a harvest >23,000 t in 1990, continuing the

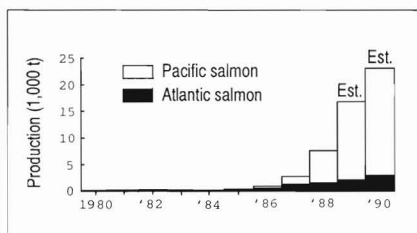


Figure 11.—Canadian farmed salmon production (live weight), 1980-90.

rapid increase in production that began in the mid-1980's (Fig. 11). In 1985, production on both coasts was <500 t. Since then, salmon farming on the Pacific coast (in British Columbia) expanded to an estimated 14,500 t in 1989, while farming on the Atlantic coast (primarily in the Bay of Fundy between Nova Scotia and New Brunswick) increased more slowly to about 3,000 t. The growth of Canadian salmon farming was helped by considerable Norwegian investment.

Pacific Region

Salmon farmers in British Columbia (B.C.) raise mostly Pacific species, including chinook (3,850 t in 1988), coho (2,000 t), and chum salmon 150 t). Chinook salmon farming is expanding in response to consumer preferences in the United States—Canada's largest export market. Chinook production in B.C. was projected to reach 16,500 t in 1990.

Salmon farmers in B.C. were said to have adopted a "gold rush" mentality in the mid-1980's, as farms were established with little regulation or coordination. More recently, however, both Government and private organizations have begun to play an important role in the development of the region's aquaculture industry. The B.C. Salmon Farmers' Association (BCSFA) now represents 95 percent of Pacific salmon farmers and has established well recognized health and quality standards. The BCSFA also performs marketing studies intended to maximize returns to farmers. A privately funded salmon research institute, Ewos Pacific Research Farm, began investigating nutrition and health issues in mid-1989.

The B.C. Government has moved to supplement these private regulatory and research efforts by forming the B.C. Aquaculture Research and Development Council in 1989. A 1988 "Memorandum of Understanding" between the B.C. Government and the Federal Department of Fisheries and Oceans clarified Federal and provincial responsibilities for aquaculture.

Atlantic Region

Salmon farms in Atlantic Canada—producing Atlantic salmon—are centered

in the "Scotia-Fundy" region located northeast of Maine. Salmon aquaculture in this region has grown at an orderly pace—in contrast to B.C.—but has also expanded more slowly than predicted. Provincial authorities in Nova Scotia and New Brunswick have adopted a cautious attitude, apparently to prevent overexpansion of the industry. The New Brunswick Government placed a moratorium on the issuance of salmon farm licenses during 1986-88 and has issued only limited numbers of licenses since then. Thus, current production levels (about 3,000 t) are not expected to increase rapidly. Even so, salmon culture in Atlantic Canada was reportedly generating C\$40 million per year in direct sales by 1988.

Salmon farms in Quebec and Newfoundland have so far produced only about 100 t of salmon per year. In an effort to determine whether higher production levels could be achieved in these coldwater areas, researchers recently conducted a 3-year experiment in Newfoundland involving in-cage heating systems and different species of salmon. The commercial feasibility of the experimental farming methods is now being evaluated.

Farms

In 1989, there were 150 active salmon farms in B.C. (200 licenses had been issued), producing an average of 100 t each. The largest concentration of farms is on the west coast of Vancouver Island. Most farmers raise salmon by using smolts from separate Government or private hatcheries, but some farmers are integrating their operations vertically by building hatcheries.

There were about 45 salmon farms operating in Atlantic Canada in 1989, most of them in the Bay of Fundy. Average annual production per farm in this region is lower than in B.C.—about 65 t. Many of the farms in Atlantic Canada are quite small; there are only a few large-scale operations. Connors Brothers company, a leading sardine canner, operates a salmon farm and a 400,000-smolt hatchery in New Brunswick, supplies fishmeal to many salmon farmers in the area, and markets salmon for other

farmers. The Sea Farms company, a Canada-Norway joint venture, operates 3 hatcheries and 3 farms which are expected to produce 1,000 t of salmon per year by 1990.

Exports

Unlike most other major salmon farming nations, Canada also operates a large wild salmon fishery. Export statistics do not explicitly distinguish between the two sources of salmon. In 1988, exports of fresh salmon from B.C., presumably including most farmed salmon, were shipped mainly to the United States (5,200 t, C\$33.1 million in 1988), followed by Japan (290 t, C\$3.0 million), and the UK (80 t, C\$0.5 million). Corresponding statistics for Atlantic Canada were not readily available. In 1989, the United States imported about \$45 million worth of fresh salmon from Canada, including \$22 million worth of Atlantic salmon (3,000 t), \$12 million worth of sockeye (2,400 t), \$8 million worth of coho (1,900 t), and \$3 million worth of pink salmon (1,700 t).

Outlook

In 1989, Canada's Fisheries and Oceans Minister, Tom Siddon, announced the release of a report entitled "Long Term Production Outlook for the Canadian Aquaculture Industry," prepared by the Price Waterhouse company. The report forecasts a "worst-case" farmed salmon production level of 31,000 t by the year 2000, and a "best-case" level of 66,000 t.

Japan

Japan is the world's largest market for salmon and the largest salmon importer. Only species of the Pacific salmon are cultured. Production in 1988 was 16,400 t and in 1989 it was estimated at 18,600 t.

Production

With its enormous market, Japan has attempted to maintain a high level of self-sufficiency in salmon supplies. As salmon fishing quotas in the North Pacific (established jointly by the Soviet Union and Japan) have been reduced in recent years, Japan has turned to two artificial methods for increasing the supply of salmon. The first method—employed on



a small scale since the 1940's—involves hatching and releasing salmon fingerlings, which are then caught several years later off the coast of Japan. This type of salmon ranching yielded 155,000 t of salmon in 1986, a 2.5 percent return rate on the 2 billion fingerlings released in 1982. The second method, coho and chinook salmon culture in sea cages, has not yet yielded comparable quantities of salmon, but it has reached significant levels in recent years (Fig. 12).

Japan's farmed salmon production has increased from 5,000 t in 1984 to an estimated 18,600 t in 1989, making Japan the world's third largest producer of cultured salmon and the largest producer of Pacific species. Unlike most other salmon producing countries, Japan apparently does not export any of its growing salmon harvests, and thus has not contributed to the recent rapid growth of farmed salmon supplies on world markets. Nevertheless, Japan's increasing salmon farming capacity may affect

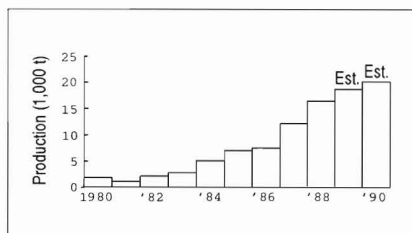


Figure 12.—Japanese farmed Pacific salmon production (live weight), 1980-90.

its import requirements, especially for fresh salmon. Production would have to increase dramatically to completely supply Japan's salmon market: In 1989, Japan imported over 135,000 t of fresh, chilled, and frozen salmon (mostly frozen Pacific species).

The Japanese Government has not played a decisive role in the establishment of the salmon farming industry, leaving its development to private companies. Partly for this reason, official information about Japanese salmon farming is limited. A nongovernment agency, the Japan Fishery Resources Conservation Association, inspects most shipments of salmon eggs imported into Japan to prevent the spread of whirling disease or viral hemorrhagic septicemia.

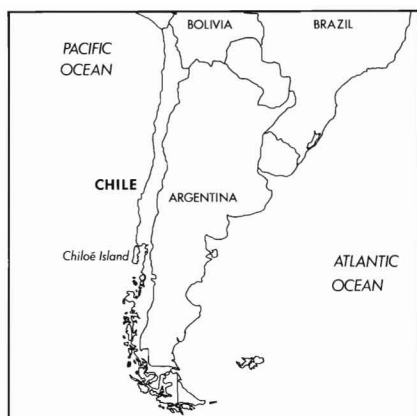
Salmon Farms

Most commercial-scale salmon farms in Japan produce coho salmon; smaller farms produce other species, including chinook. There were an estimated 377 coho salmon farms active in Japan in 1989, compared to 326 farms in 1988. Most of these farms (329) are located in Miyagi Prefecture, about 200 miles north of Tokyo. Smolts are supplied by about 130 freshwater farms, using fertilized coho eggs imported primarily from the United States.

Nichimo Fishing Corporation, a major Japanese company, built the first Japanese salmon farm in the early 1970's, prompted by the decline in North Pacific salmon fishing quotas. The company has continued to be the leading producer of coho salmon, and has recently begun to produce cherry salmon, chinook salmon, and hybrid salmon species. In addition, the company is attempting to reduce dependence on imported eggs; it has successfully raised salmon from eggs hatched in Japan. Other important salmon farming companies include Nichiro and Taiyo. The Mitsubishi Corporation has recently joined the Niigata Iron and Steel Company and the Hokkaido Prefectural Fish Hatchery in a feasibility study of raising Atlantic salmon.

Outlook

Japanese production of farmed Pacific salmon will continue to increase. Coho



egg imports from the United States, which largely determine coho salmon production with 2-3 years lag, increased from 28 million in 1986-87 to 44 million in 1988. If past production rates continue, this level of coho egg imports could yield as much as 30,000 t of salmon in 1990 or 1991.

Chile

Chile is another nation that farms both Atlantic and Pacific salmon species. The harvest for 1988 totalled 3,100 t, and for 1989 the total was estimated at 6,508 t.

Production

Chilean salmon growers expected to harvest over 12,000 t of farmed Atlantic and Pacific salmon in 1990, double the estimated 6,500 t harvested in 1989 (Fig. 13). Salmon culture is Chile's fastest growing economic activity. At current growth rates, the salmon culture industry could well become the leading sector of the country's dynamic fishing industry, supplanting Chile's massive fishmeal in-

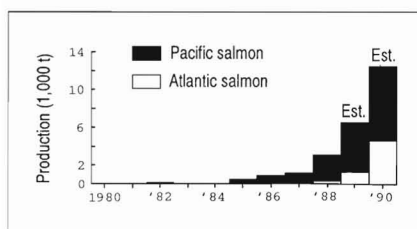


Figure 13.—Chilean farmed salmon production (live weight), 1980-90.

dustry. Salmon farmers initially cultured Pacific coho salmon, but the involvement of Norwegian and British companies has made possible diversification into Atlantic salmon. Many farmers are also working with Pacific chinook salmon and sea-farmed trout ("salmon-trout"). Harvests of sockeye and cherry salmon are also planned.

Salmon culture is a new industry in Chile. Farmers first harvested more than 1,000 t as late as 1987. Several large foreign companies have subsequently entered the industry, permitting substantial production increases. The participation of major salmon culture companies from Norway, the UK, and Japan has meant an infusion of technology and capital which is enabling the Chilean industry to evolve rapidly from a small-scale operation to an increasingly important sector of the country's fishing industry. Harvests in 1993 could be close to 30,000 t, equivalent to current UK salmon production levels. Some observers believe that the Chilean industry will eventually rival the massive Norwegian industry. Chilean production costs are generally below those of its major competitors, primarily because of lower feed costs: Chile is a major fishmeal producer.

Farms

The Chilean coast is similar to the Norwegian coast, with large numbers of well sheltered sites which are ideally suited for salmon farms. Many additional sites are still available along the coast south of Chiloé Island, where the industry is now centered. Farmers are reporting excellent

yields with growth rates exceeding some of the best Scottish and Norwegian operations. (The latitude of Chiloé Island is about 40 degrees, compared with Oslo's latitude of about 60 degrees.) Salmon farmers still rely heavily on imported fertilized salmon eggs, but a small domestic smolt-producing industry is developing. An estimated 25 companies produced salmon smolts in 1989. Salmon farmers in Chile hope to develop a "native species" of disease-resistant farmed salmon.

Exports

Chilean salmon farmers initially marketed their harvests largely fresh in the United States. In 1988-89, however, exports to Japan increased markedly (Table 8 for 1988). In 1989, Chilean exports of frozen salmon to Japan reached 3,970 t, worth \$24 million. Prospects for European sales are unfavorable because of relatively high freight charges to Europe and competition with European producers.

Outlook

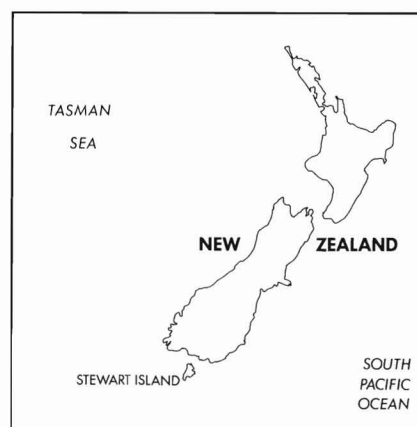
Even in an environment of declining prices, Chilean salmon producers are well situated to compete successfully because of their low cost structure, high quality standards, species diversification, and successful penetration of both the Japanese and U.S. markets.

New Zealand

Salmon farming in New Zealand is a relatively new industry, and it is limited

Table 8.—Chile's exports of farmed salmon by country of destination, 1986-88, by value.

Destination	Exports (\$1,000)		
	1986	1987	1988
United States	3,237	5,000	9,232
Japan	120	83	7,561
Netherlands	0	57	979
France	6	0	834
Brazil	103	100	259
Argentina	68	107	189
Italy	0	34	136
Belgium	0	25	12
Canada	41	0	0
Others	11	30	398
Total	3,586	5,436	19,600



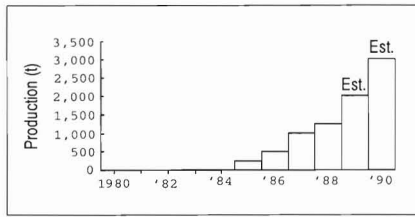


Figure 14.—New Zealand farmed Pacific salmon production (live weight), 1980-90.

to culture of Pacific salmon, largely the chinook. The first salmon farm was established in 1978. Many farmers began to raise salmon on a small scale after first operating other aquaculture ventures such as mussel farms.

Production

New Zealand's salmon production has increased rapidly in recent years (Fig. 14). While it has yet to become a major producer, New Zealand's salmon output is significant because farmers produce commercial quantities of chinook salmon, a species which is not yet farmed on a large scale anywhere else except in Canada. Exact figures for production by species are not available, but in 1988, production was 1,250 t, while in 1989 New Zealand's salmon farms reportedly had the capacity to produce 2,000 t of chinook salmon per year.

Farms

There were about 43 salmon culture operations in New Zealand as of early 1988, the latest year for which data were available. Of these, 12 were ocean ranches, 15 were sea-cage farms, 15 were fresh-water pond farms, and 1 was an onshore seawater farm. Most farmers and ranchers raised chinook salmon. At least 9 farms also produced sockeye salmon, but output had not yet reached commercial levels. All farms are licensed by the Government. Eggs are provided primarily by the New Zealand Salmon Company's hatchery, which produces up to 10 million eggs per year.

Salmon farmers in New Zealand have faced both natural and man-made obstacles to expansion. In early 1989, about

600 t (out of a total of 1,400-1,500 t of penned chinook salmon) were lost after an algae bloom struck a group of farms on Stewart Island, the center of the salmon farming industry. On that occasion, farmers were hindered in their efforts to save stocks by a Government regulation restricting salmon farms to Glory Bay, where the algae bloom was most pronounced. After these serious losses, farmers petitioned the Government to relax some of the restrictions placed on salmon farms. However, the control of salmon farming remains a sensitive issue in New Zealand, where protecting the environment is a priority. Ironically, the algae bloom which destroyed a significant portion of salmon stocks in early 1989 also heightened concerns that salmon farming had disturbed the natural environment. (Later research, however, has apparently shown that the algae infestation was caused by natural conditions.) Despite the irritation that salmon farmers express concerning strict controls on their industry, Government regulations have played a role in protecting New Zealand's salmon farms from disease outbreaks. Farms have been briefly quarantined after salmon were discovered to have whirling disease.

Apart from regulatory control, another factor in the slow growth of New Zealand's salmon farming capacity is opposition from native peoples, such as the Maoris, who own prime coastal land. Potential salmon farming ventures have faced long bureaucratic delays as applications for leases are reviewed.

Exports

Most of New Zealand's salmon production is exported to the United States and Japan. In 1986, 75 percent of its exports were sold to the United States, but in recent years the emphasis has shifted overwhelmingly toward Japan. In 1989, New Zealand exported 960 t, worth \$5.6 million to Japan, but only about 1 t to the United States. Most exports are shipped frozen, rather than fresh.

New Zealand's southern-hemisphere location is advantageous for salmon exports, because—like Chile—its harvests are available during the northern hemisphere's salmon culture off-season (June-



August). Furthermore, by producing chinook salmon, New Zealand's farmers have entered a market in which there is limited competition from other salmon farming nations. On the other hand, New Zealand's salmon exporters face the disadvantage of high transport costs.

Australia

Salmon farming in Australia began in 1985 when the Tasmanian Government and Norway's Noraqua Group established a joint venture (called Tassal Ltd.) to produce Atlantic salmon, still the only species. That company has become the country's largest producer, and other Atlantic salmon farms have opened both in Tasmania and in western Australia. The prospects for development of salmon farming in Australia are good because of favorable natural conditions and because of the presence of experienced farmers from both Norway and Scotland. In addition, many salmon farmers in Australia have experience in raising trout and are thus prepared for some of the difficult technical issues involved in raising salmon.

Production

Most farmed salmon in Australia is sold on the domestic market. In 1989, however, Australia exported 280 t, worth \$3 million, to Japan. Salmon production for 1988-89 was 380 t total, and for 1989-90 it was estimated at 2,000 t.

Farms

Australian salmon farms are concen-

trated on the island of Tasmania, south of the mainland, where natural conditions favor rapid growth. In 1987, the latest year for which data are available, there were 26 farms licensed to raise salmon in Tasmania (and 23 farms were licensed to grow rainbow trout). The 4 largest farms on the island are operated by the Tassal company, the joint venture with Norway, which has established an integrated operation controlling production from the smolt stage through harvesting, processing, and marketing.

At least two companies—the Marine Industries company and the Australian Seafarms company—have opened salmon farms on the southwest coast of Australia, near Perth. Marine Industries operates tank farms for production of rainbow trout and was planning to use a similar system for production of salmon. In 1987, that company was forecasting harvests of about 500 t per year by 1992, while Australian Seafarms was forecasting production of 300 t per year by 1991 and 1,000 t per year by 1994. Actual pro-

duction figures for the companies were not available as this report was being prepared.

Literature Cited

- DPA Group, Inc. 1989. Cost production model for pen rearing of salmon in Alaska and other producing regions. *In* R. Mendez and C. Munita, *La salmonicultura en Chile*. Fundacion Chile.
- Mendez, R., and C. Munita. 1989. *La salmonicultura en Chile*. Fundacion Chile.
- Shaw, S. A., and A. Curry. 1969. Markets in Europe for selected aquaculture species. FAO-GLOBEFISH, Rome, July.