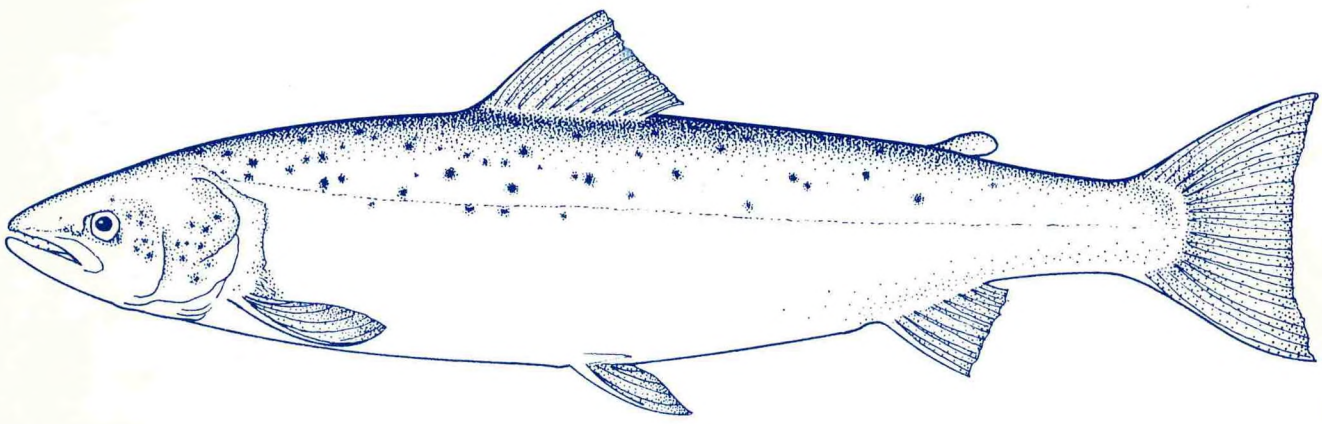
World Salmon Culture



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World Salmon Culture

Europe, North and South America, and Pacific

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FOREWORD

The Office of International Affairs follows the development of the world's farmed salmon industry. During the past decade the Office has accumulated an impressive collection of information from around the world. We depend heavily on the efforts of the U.S. Embassies and Consulates overseas for current information.

The Office of International Affairs neither supports nor opposes the development of salmon farming or the practices of any single or group of salmon producing nations. The Office has tried to explain what has occurred in the world farmed salmon industry in a factual, responsible manner. We recognize that recent events have disrupted markets and resulted in economic dislocations. We believe that it is important to report these developments in a constructive way and identify both the problems and possible solutions needed to avoid similar problems in the future.

In some instances, brand names or the names of companies have been included. **It is not the policy of the U.S. Department of Commerce to endorse any product or company.** Likewise, the omission of any product or company is not an indication of any disapproval by the Department of Commerce.

The authors are aware of statistical discrepancies in some of the tables provided. Whenever possible we have used the information provided by the U.S. Foreign Service in the host country as our ultimate source. *It was also decided that it was better to include incomplete or possibly inaccurate information than to exclude the information entirely.* In some cases the information, even though misleading, reveals a trend that can be useful. In other cases the information, although inaccurate, was generally close to other statistical data and provides readers with an overall picture of important developments. The authors believe that the accuracy of statistical data has improved in recent years and encourages readers to share their knowledge for the benefit of future reports.

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Photographs by: William B. Folsom. This publication includes the insignia of various salmon farmers' trade organizations. Credit for that work belongs to the association. In some cases the artwork may be copyrighted or registered. Line art for each geographic section was provided courtesy of the Association of Chilean Salmon Farmers.

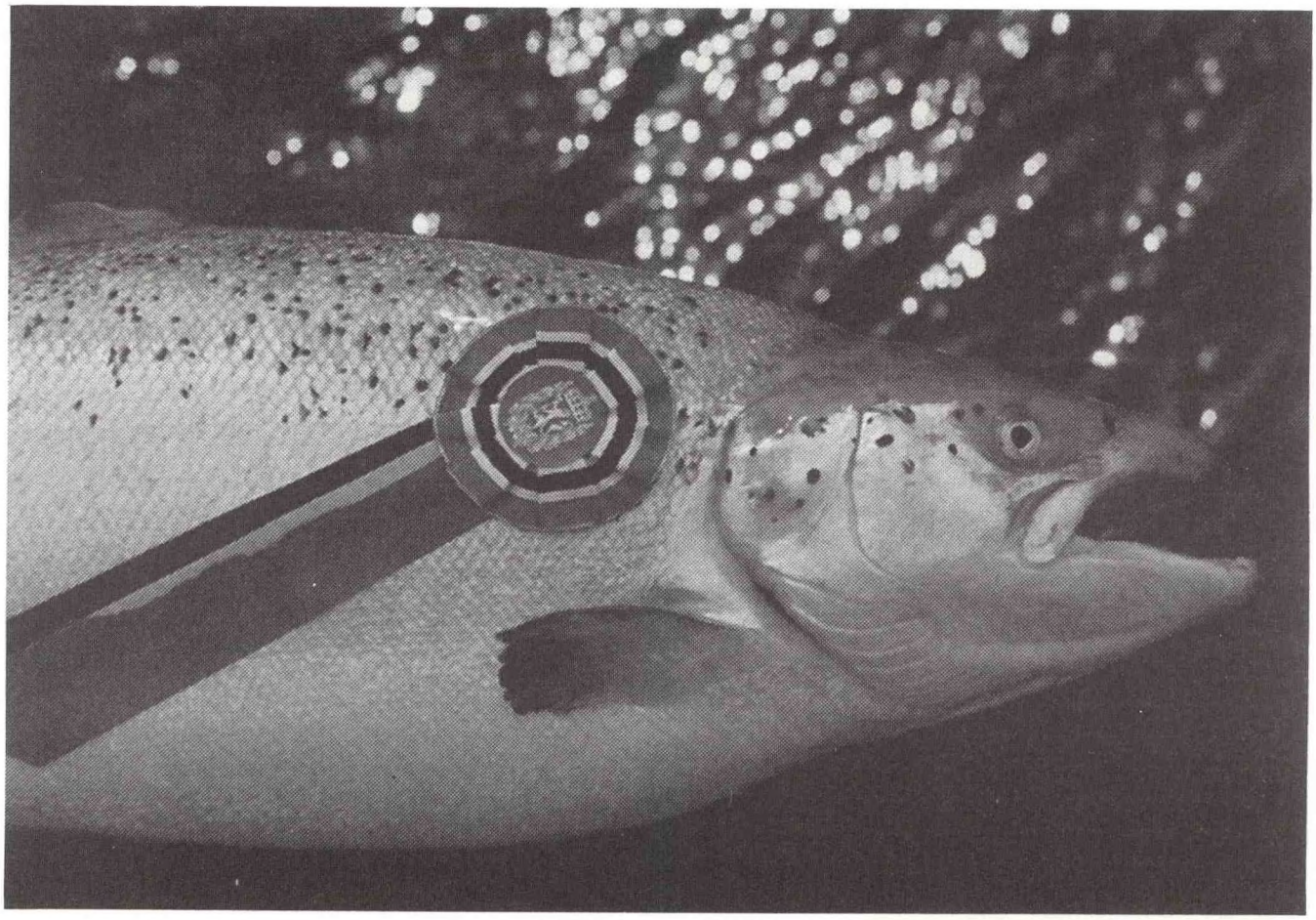


***Figure 1.**--Farmed Atlantic salmon from Norway.*

INTRODUCTION

World farmed salmon harvests peaked at slightly over 325,000 metric tons (t) worth over $1.5 billion in 1991.[1] World salmon harvests are projected to decline to about 300,000 t in 1992. This decrease follows a surge in Norwegian farmed salmon harvests from 84,000 t in 1988 to 158,000 t in 1991. Norwegian salmon farmers began harvesting more salmon than they could profitably sell in 1989 when production increased by 31,000 t (about the size of Scotland's total harvest) over 1988 harvests. In early 1990, Norwegian producers began freezing significant quantities of salmon in order to siphon off excess quantities and protect the huge Norwegian industry by stabilizing fresh salmon prices. The action, however, failed to halt the Norwegian harvest which increased by an additional 43,000 t over the 1989 harvest and helped establish a record harvest of nearly 158,000 tons. The problem of increasing harvests was not simply a matter of increasing quantities, but rather the inability of skilled Norwegian exporters to market the harvests profitably. The failure to maintain prices and to expand markets led to major market disruptions around the world. This triggered a downward spiral in world salmon prices that hurt salmon farmers around the world. The United States initiated anti-dumping and countervailing duties on imported Norwegian salmon in 1990-91; this sharply reduced Norway's exports to the United States and added to Norway's inventories of unsold salmon. In 1991, the Norwegian Salmon Farmers Exporters Organization filed for bankruptcy as it struggled to dispose of the "mountain" of unsold fresh and frozen salmon. The outlook for Norway is for a reduction in harvests to about 120,000 t during 1992.

Canada, Chile, the Faroe Islands, Iceland, Ireland, Japan, and the United Kingdom (Scotland) are other important producers of farmed salmon. These countries, although suffering economic dislocation as a result of Norway's production, expect to expand their harvests and marketing efforts in the next few years. Australia, Finland, France, New Zealand, Spain, and Sweden are still in the early stages of development but could modestly expand their production in the 1990s. Turkey and the Republic of Korea have reportedly begun salmon farming operations within the last 2 years. Russia has a tremendous potential for raising farmed salmon. The Russians have a long tradition of releasing salmon smolts into the sea along their Pacific coastline. They are, thus, familiar with the science of salmon cultivation. If the Russians decide to enter into joint venture salmon farming operations, they could become very serious competitors in a few years.

Although record harvests have been reached, tremendous technical breakthroughs can be anticipated before the turn of the century. Salmon farmers will produce more salmon, more efficiently in the next few years. Scientists are working to improve salmon through salmon husbandry, nutritional research, and other studies. The results will be faster growing salmon that are more resistant to disease and unable to spawn if they escape from captivity. New techniques will be used to reduce stress in farmed fish and to reduce the impact of fish farming on the environment.

I. HISTORIC OVERVIEW

Salmon fisheries have long been both culturally and economically vital to the peoples of many North Atlantic and North Pacific lands. Salmon culture had its origins as a restocking effort to supplement wild fisheries. German biologists began hatching salmon eggs as farm back as 1763.[2] Finnish fishery biologists reportedly were restocking salmon rivers as early as 1771. Scottish fishery biologists first attempted to incubate and hatch salmon eggs in 1838 as part of a program to increase salmon runs for recreational and commercial fishermen.[3] Irish biologists first began rearing salmonids in hatcheries in the 1860's.[4] The first hatchery for Pacific salmon was built in California in 1870.[5] Chilean biologists began experimenting with establishing non-native salmonid species in 1905. The first Norwegian effort to culture the sea-going race of rainbow trout[6] (steelhead trout) began in 1912; the project failed when heavy seas smashed the pens, allowing the fish to escape.[7] Efforts to raise salmonids as food fish are fairly recent and began in earnest during the mid-1950s when Norwegian biologists began experimenting with Atlantic salmon smolts[8]. Experimental farming of Atlantic salmon in the British Isles started at Loch Sween on the west coast of Scotland in 1960.[9] These efforts were quite successful, and pioneering commercial culture began in Norway and Scotland in the mid-1960s.[10]

II. BIOLOGY

A. Species

There are 7 commercially important species of salmon. These include 1 species of Atlantic salmon and 6-7 species of Pacific salmon[11]. Atlantic salmon *(Salmo salar)* belongs to the genus ***Salmo*** of the *Salmonidae* family. Pacific salmon belong to the genus ***Oncorhynchus*** of the *Salmonidae* family. The most common and commercially important Pacific salmon include: **chinook or king salmon** (*Oncorhynchus tshawytscha*), **coho or silver salmon** (*O. kisutch*), **sockeye or red salmon** (*O. nerka*), **chum or dog salmon** (*O. keta*), **pink or humpback salmon** (*O. gorbuscha*), and **cherry salmon** (*O. masou*). In 1989, the **rainbow** (or **steelhead) trout** was reclassified as *Oncorhynchus mykiss* (formerly it was identified as *Salmo gairdneri*)[12] adding it to the list of Pacific salmon.

B. Life cycle of wild salmon

Salmon are an "anadromous" species which are born in freshwater, descend into the sea to feed and mature, and return as adults to spawn in their natal rivers and streams. The salmon typically spawn in the summer or fall, depending on the species. Females seek stream beds composed of gravel where they dig nests to deposit eggs. Females normally lay up to 1,800 eggs per kilogram (kg) of body weight. The eggs are fertilized by a male and covered with gravel by the female. Pacific salmon species die shortly after mating.[13] Atlantic salmon, however, are able to spawn up to 6 times. Some Atlantic salmon (called kelts) remain in freshwater until the spring, when they migrate back to the sea. The eggs hatch in March or April. The young salmon fry (called "alevins") have a yolk sack which sustains them until about May or June when they begin to feed on small aquatic organisms. The fry remain in freshwater for about a year when they develop into "parr" with a distinctive "thumb print" on their sides. The parr remain in freshwater until they undergo the physical change known as "smoltification" which prepares them for life in the ocean. The smolts migrate to the sea where they will feed for several years before returning to spawn[14] and begin the cycle over again. Actual growth rates and spawning times vary according to the species of Atlantic or Pacific salmon being considered.

C. Cultured salmon life stages

The Atlantic, coho, and chinook salmon are most commonly raised commercially throughout the world. Cherry salmon is grown in Japan. Small quantities of pink and cherry salmon are also being raised in Chile.

1. Egg to larvae

The process of raising salmon begins with broodstock which are male and female salmon selected to provide desirable traits.[15] Producers carefully strip eggs from the female. The eggs are fertilized with milt from the male and transported to a hatchery where they are kept in incubation tanks in a carefully controlled environment. Following an incubation period of about 2 months, yolk-sac larvae emerge (called "eyed eggs").

2. Alevins to fry

The eyed eggs gradually lose their egg yolk as the nutrients are absorbed. At that stage they are called "alevins" and are visible as tiny fish. The first few months are critical to survival and there is usually a high rate of mortality during that time. About 1 month after the alevins start feeding, markings appear and they are known as salmon "fry."

3. Fry to parr

After a few months the fry are transferred from small tanks to a large, freshwater, "grow-out" tank. These tanks are generally outdoors and are usually protected from predation by birds or animals. The fry grow quickly during the summer months and by the fall have matured into "parr". Parr remain in their tanks until they lose their juvenile markings and prepare to undergo a major physiological change about a year after hatching.

4. Smolts

The salmon parr undergo "smoltification," which prepares them for life in saltwater. The smoltification process includes changes in the shape, color, and density of the parr. During smoltification the parr lose their juvenile markings which are replaced with a bright, silver skin. These anatomical changes prepare them to change from a freshwater environment to a saltwater environment.[16] The transformation includes different behavioral patterns as the fish changes from one that prefers to swim

against the current to one that prefers to swim in the same direction as the current and in shoals.[17] The smolts (which weigh about 40 grams) can be sold to salmon farmers shortly after the process is completed. Smolts are taken to fish farms in live tanks carried in ships, large tanker trucks, or sometimes hoisted aloft by helicopters. After being placed in enclosed pens the smolts are fed special diets to promote rapid growth. Growth is the greatest during warm summer months when feeding takes place frequently. In winter, the fish are less active and feeding usually takes place only twice a day.

5. Market-sized salmon

Harvesting of farmed salmon is determined by weight but usually occurs before the fish reach sexual maturity[18]. When salmon reach sexual maturity, the quality of the flesh is reduced and it loses its appealing flavor and color.[19] The weight and size of "market-sized" fish can vary depending upon the species, the requirements of processors, and consumer preferences. The preferred market size for Atlantic salmon ranges from 2 to 5 kg, while pink salmon average 2 kg, sockeye 3 kg, chum 4 kg, coho 5 kg, and chinook 10 kilograms. Many farmed coho and some chinook are harvested as "pan-sized" fish, and they average from 500 grams to 700 grams in weight. Different salmon smokers require fish with a specific fat content, depending on their smoking methods and preferences.

6. Mature salmon

Most salmon reach sexual maturity about 28 months after smoltification. Sexual maturation in salmon involves the utilization of body fats, protein, and carbohydrates to create the reproductive organs (ovaries and testes) as well as the eggs or milt needed to reproduce. The fat used in this process also contains concentrations of carotenoid which provide the salmon's characteristic pink or red color. In some countries, such as Japan, the red color of the flesh is an important consumer preference. Thus, it is important to harvest the fish when the flesh is a rich red color. As the salmon's nutrients are depleted, the flesh becomes pale, watery, and tasteless. Growers harvest and sell their crop before this process starts.[20] Scientists are working to develop sterile fish that do not mature, which would obviate this problem in the future. Sexually mature salmon can be kept for use as broodstock.

III. PROBLEMS OF SALMON CULTURE

A. Overview

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 generated by farmed salmon or to pens that block access to fishing grounds. Landowners and tourist organizations have objected to the installation of salmon farms on scenic stretches of coast which are important for tourism. Sportsfishermen fear that fish farms are responsible for killing off wild gamefish. Scientists are concerned about the long-term impact of fish farming on the marine environment. Ecologists are concerned about the use of toxic chemicals or antibiotics which are introduced into the ocean. Environmentalists are worried about marine mammals becoming attracted to the pens as a source of food and then becoming entangled in the netting. Even bird lovers are upset when they hear stories of herons, egrets, or osprey being killed to keep them from feeding at grow-out pens.

Fears about potential problems generate strong opposition to fish farms. This is especially true when new (or exotic) species are being introduced into non-native waters. Many of these concerns are legitimate. The potential for environmental damage, however, is sometimes exaggerated or is no longer as severe, thanks to advances in technology, medicine, and fish farming techniques. In summary, not all issues have been solved, but many have or will be in the future; each application for new farm permit should be carefully examined on a case-by-case basis.[21] The following identifies some of the key problems associated with raising farmed salmon and some recent developments that have mitigated the adverse impacts of these issues on the environment.

B. Environmental problems

Salmon culture and the aquatic environment are interdependent. Salmon farming requires waters that are free of harmful chemicals, organic pollutants, and pathogenic microorganisms. However, salmon culture degrades its surroundings by introducing harsh or toxic chemicals into the environment, adding to the nutrient content of local waters (through fish

excrement and uneaten feed), using medications to treat diseases, and threatening wild salmon stocks through the possibility of farmed salmon escaping and genetically compromising wild populations.

1. Antibiotics

Water pollution caused by organic wastes from salmon farms can reduce growth and disease resistance. Water pollution, in turn, causes stress in farmed salmon. This frequently leads to increased use of medication. Excess medication then becomes a pollutant. Because antibiotics and other chemicals enter the marine environment, medications not only effect the cultured salmon but the entire ecosystem around the site as well. Researchers at Bergen's Institute of Marine Research, for example, have found high concentrations of medicine in wild fish found near fish farms and speculate that medicated fish feed is being eaten by wild fish. Blood tests revealed high concentrations of residues in fish caught within 400 meters of farms at least 2 weeks after medication of farmed fish had ceased. Vaccines have been developed in recent years, allowing farmers to reduce the use of antibiotics, even though the number of fish being cultured has increased dramatically. Vaccines are administered to individual smolts or salmon, thus avoiding the problem of spreading medications beyond the farm system. Health officials around the world are emphasizing preventive medicine and strict sanitary practices to avoid diseases and to contain diseases once detected. Finally, trials are underway to breed more disease-resistant smolts. These efforts have significantly lowered the quantity of antibiotics needed in salmon farming and are reducing the amount of medications introduced into the marine environment.

2. Deep-sea pens

Deep-sea salmon pens are growing increasingly important in the development of salmon farming. In some countries, such as Ireland and the Faroe Islands, the use of deep-sea salmon pens has become quite common. There are several reasons for this development. First, the constant movement of water provides a desirable level of purity for growing salmon. Most waste products (natural or man-made) are dispersed by ocean currents. Second, the constant motion of the water forces the fish to swim constantly, thus yielding leaner, healthier fish. Third, the number of potential farm sites in many coastal areas has become limited, either by physical limits (e.g., areas with poor tidal flushing action) or because of public objections. Since the facilities are well offshore, there are few objections from landowners or tourists. Fourth, deep-sea pens offer fish farmers opportunities to expand the holding capacities of their farms, generating savings from large-scale, cost-cutting operations. Fifth, crowding can be minimized, producing less stress on fish and reducing the need for medication. Finally, operations in the Faroe Islands suggest that they may be more efficient to operate than coastal facilities.

Offshore fish farms are not, however, entirely without problems. These large offshore facilities can interfere with maritime traffic. The placement of the facilities can also interfere with commercial fishing. The ability of these systems to survive gale-force storms is also uncertain. For example, a winter storm with winds of 150 miles per hour destroyed several farms designed to withstand gale force winds in the Faroe Islands in the winter of 1988-89. There are also a number of unknown factors that should be considered. There have been few studies of the long-term impact of waste disposal in the offshore areas; the impact may be minimal, but information about this topic is simply not available. There is also an increased possibility of interference with migrating or foraging marine mammals. This is another area where little or no information is available. Finally, these facilities are also subject to algae blooms since they are not built to be moved quickly.

3. Destruction of living resources

Fish farms have been identified as the source of toxic materials or pathogens responsible for destroying living aquatic or marine resources in the vicinity of the operation. British scientists have confirmed that Nuvan, a toxic compound used to treat sea lice (see below) has accumulated in shallow depressions in the vicinity of fish farms. The concentration gradually breaks down, but also impacts fish that swim through the mass. British scientists have reported a high incidence of blindness in fish that is thought to be associated with excess concentrations of Nuvan. Tributyltin (TBT, a highly toxic tin-based antifoulant paint) was used by some British fish farmers to treat the nets in their holding pens. The tributyltin leeched into local waters, destroying beds of shellfish. The use of tributyltin has been banned in EC countries, but still is still permitted in other countries.

Irish sportsfishermen and the owners of hotels or lodges catering to sportsfishermen have frequently complained that local sea trout stocks have been adversely impacted by Ireland's salmon farms.[22] The

possibility remains that some species of fish might be more vulnerable to chemicals used to treat fish farms, and that habitat or other degradation might have occurred that would alter the life patterns of some fish.

4. Excess feed

Salmon feed usually consists of dry pellets or moist mixtures composed of fishmeal, oils, shrimp shells and special additives.[23] The high oil content of capelin and sandeels makes it an excellent food that produces high growth rates and thus is preferred in many Atlantic salmon farms. Shrimp shells are used to enhance or standardize the flesh color of salmon. The use of natural feeds allows fish farmers to reduce or eliminate the use of artificial food coloring agents, permitting promotion stressing the fish as a "natural" seafood.[24] Less than 10 years ago, salmon farmers needed more than 2 kg of dry feed to produce 1 kg of salmon. Nutritional scientists have recently been able to produce 1 kg of salmon from only 1.1 to 1.2 kgs of dry feed, representing an excellent use of feed.[25] It is clear that nutritional work has yielded significant reductions in feed use in recent years and that fish farmers will benefit from these developments through lower production costs. In addition, the environment will benefit through reduced accumulation of waste near fish pens.

5. Genetic pollution

A major concern to marine biologists around the world is the potential problem of escaped farmed salmon. Farmed salmon typically come from broodstock that have been husbanded for certain traits, such as fast growth or the ability to withstand stress in a highly stocked environment. Farmed salmon do not have the same genetic traits found in wild salmon. In many cases, salmon in culture pens come from strains of broodstock not natural to the area where they are farmed. Many of Ireland's salmon, for example, came from Iceland. Should farmed salmon mate with wild salmon, it weakens the natural traits of the wild salmon, such as their ability to locate "their" natal rivers. In some countries this is a major problem; in others it is less of a concern. In January 1992, for example, a major storm lashed the coast of Norway smashing salmon pens and releasing an estimated 1 million Atlantic salmon into the ocean. Norwegian officials are very concerned that these salmon will join wild salmon on their migration up rivers and will spawn. This will harm the genetic makeup of the wild stocks and will "pollute" the strains of wild salmon in Norway's river systems. This contrasts with the experience in British Columbia where Atlantic salmon have not been able to spawn with Pacific salmon species after escaping.

6. Genetic manipulation

Scientists have experimented with developing triploid salmon which are sterile and thus would pose no genetic threat to wild stocks. Some of the earlier experiments involved genetic work.[26] The development of a triploid salmon would be a solution to an important environmental problem. Genetic manipulation, however, raises questions about consumer fears. The Norwegian Fish Farmers Association, for example, strongly opposes any genetic manipulation of any fish raised in Norway for human consumption.[27] The European Salmon Growers Association (ESGA) also opposes the use of recombinant hormones and genetic manipulation of salmon. ESGA members passed resolutions against genetic manipulation as early as 1986. The ESGA general assembly, in 1991, passed a resolution indicating that genetic engineering of salmon would be "potentially extremely damaging to the marketing of salmon." This resolution was reconfirmed at the ESGA general assembly in 1992.[28]

7. Interactions with wildlife

Pens filled with salmon are a natural attraction to any large, hungry, marine mammal. The damage caused by a massive sea lion, or seal can be substantial, and most encounters result in some damage to the pen. In many instances, these encounters lead to fish escaping and sometimes to the marine mammal being caught in the net and dying. In some instances, fish farmers deal with the situation by shooting the offending animal or by attempting to scare the animal away. In parts of Scotland, predation by seals is a serious problem for salmon farms, resulting in damage to pens and stock losses. It has also led to confrontations with environmental groups demanding that the farmers comply with regulations prohibiting the harming of marine mammals. The use of noise machines, used to scare off animals, is generally not very effective and mostly elicit complaints from landowners. The most common method of keeping unwanted visitors (mammals or birds) includes a double wall of netting to deter entry.

Sea birds and small wading birds are also attracted to pens filled with smolts. Herons, egrets, and other birds are attracted to pens holding larger

fish. Despite elaborate mesh nets overhead, there are always stories about enterprising birds managing to get through the netting and feeding on the fish in the pen. This problem of bird predation is not as significant as that reported by catfish farmers in the United States, but it is cause for concern among fish farmers. Fortunately, a small salmon pen can be easily and inexpensively covered whereas an open pond comprising several acres is much more difficult to enclose. There are also problems associated with predation by animals (such as martens, weasels, rats, and other small animals indigenous to local fish farms). Efforts to control bird or animal predation can cause adverse publicity among naturalists. Poachers are also attracted to pens brimming with expensive salmon waiting to be harvested illegally. This requires special alarm systems and other devices to prevent salmon from being harvested without the approval of the owners.

8. Organic wastes

Early salmon farms were located in protected fjords or bays which had poor flushing capabilities, leading to an accumulation of fish feces and excess feed underneath the pens. When these waste products accumulate, they begin to break down. The decomposition process releases ammonia, hydrogen sulfide, and methane. Such waste byproducts are not only harmful to the salmon in the pens above this rotting material, but are to other aquatic organisms. The process also reduces oxygen levels and produces a fertile environment for the growth of bacteria and other microorganisms. The process additionally releases strong odors into the air which can generate complaints by neighboring landowners. Nutritionists are studying ways to optimize food consumption; better food consumption reduces both food loss and waste byproducts. In addition, because of stronger grow-out systems, salmon farmers can anchor their pens further offshore in more exposed locations. There is now a premium placed on water flow to insure an ever changing water supply through and around pens. No studies have been conducted on the long-term impact of dispersal of waste products from salmon farms on the highseas marine environment; this issue may return in the future as a new problem. When salmon farming first began in Norway, the fjords were thought to be too large to be impacted, although it is now known that some fjord systems have been adversely impacted by waste products from salmon farms. Scottish salmon farmers are participating in a move designed to leave sites fallow for a year. Not only does this aid in the control of disease, but it also allows the seabed to recover.

9. Parasites

Sea lice: These small crustaceans (*Lepeophtheirus*) are a nuisance to salmon farmers. Sea lice attach themselves to salmon and feed on their flesh. The result is an unsightly blemish that damages the appearance of salmon. In heavy infestations, the fish attempt to rub themselves against nets or tanks, causing lesions which can become infected. Though sea lice also infect wild salmon, the high intensity of salmon farming has led to infections much more severe than those found in the wild. In the past, salmon farmers used a variety of chemical treatments (including Nuvan or Aquaguard, which has since been widely banned as a toxic pollutant) to control the lice. The problem, of course, was that the chemicals remain in the marine environment following applications and repeated applications were needed during the growth process. Indeed, high concentrations of excess medications used in "dipping" salmon for sea lice infection were found in fish living around salmon pens. A further problem with "dipping" salmon is that the treatment caused the salmon severe stress. Salmon farmers could expect slowed growth and higher fish mortality in direct proportion to the frequency of dips -- not just because of the infection, but due to the treatment itself.

Norwegian scientists recently discovered a non-toxic method of fighting salmon lice by using a natural product extracted from ground chrysanthemum flowers.[29] The product, so safe that it is approved for use in food processing, is mixed with oil and poured on the surface of a fish pen to form a layer of medication. When the salmon jump, the extract covers their skin and kills the lice without harming the fish.[30] Norwegian salmon farms are also delousing their salmon stocks using "cleaner fish." These fish, which feed partially or exclusively on the small crustaceans, can apparently replace the costly, environmentally damaging, chemical delousing process. In industry trials using species of wrasse (such as *Ctenolabrus rupestris*), 1 wrasse to every 50 salmon decreased the need for chemical delousing by over 75 percent. This lowers the costs of delousing in time, chemicals, and fish loss (lost weight and mortality) by over 50 percent.[31] A third such natural treatment for sea lice involves placing cut onions in salmon pens, which repels the small crustaceans. This very cost effective method is also receiving industry trials in Norway and the British Isles. Finally, scientists report an even more interesting discovery: salmon lice congregate near the surface in shallow bays. By allowing penned salmon to live in

deeper water -- below 10 meters -- the problem of sea lice virtually disappears.[32] This solution should result in a considerably reduced need for chemical sea lice treatment, but involves expenditures to build deeper holding pens for the salmon.

Other: The Norwegians introduced wild salmon from Sweden several years ago. The salmon were infected by a parasite called *Gyrodactylus salaris*. The parasite has spread rapidly throughout Norway's rivers and has devastated Norway's wild salmon during their freshwater fry stage. This is one important example of how a "harmless" parasite of one species in one environment can have a devastating impact on the same species in a different environment. The introduction of new or "exotic" species into a new environment poses certain risks and *Gyrodactylus salaris* is one example of the problem at its worst. Fishery scientists and administrators need to be aware of the potential for significant damage to native stocks when introducing new species.

10. Scenic degradation

As increasing numbers of salmon farms have appeared, a growing number of landowners have begun to complain about the aesthetic degradation of once pristine coastal areas. In some instances they have been joined by those dependent upon tourist income. This is particularly true in parts of Scotland and Ireland where this issue has gained considerable prominence in recent years. The alternatives are to seek more remote, less visible locations, or to move offshore. The concern about scenic degradation has even surfaced in Norway in recent years. One area where scenic concerns are unlikely to hinder economic development is Russia where farming salmon might become an important industry in the next decade.

C. Commercial problems

Fish farming also poses problems for those who invest their time, energies, and capital in operating salmon farms. It is important that entrepreneurs are also aware of potential dangers that could adversely impact their operations. These are generally dangers that come from the environment and are not caused by fish farming.

1. Adverse weather

Many manufacturers of high-seas salmon farming systems claim that their pens are designed to withstand the worst weather. However, experience has shown that harsh winter storms can damage pens. A very strong storm destroyed many cages and released millions of salmon along the western coast of Norway on January 1, 1992. Scottish producers suffered some damage from this winter storm, but Scottish losses were comparatively light, and the ecological consequences of farmed salmon losses was not a major concern in Scotland.[33] Faroese salmon farmers suffered massive losses during the winter of 1988 when a storm packing winds over 150 miles per hour smashed through the Faroe Islands. Heavy weather or freak storms continue to pose problems for the industry and the environment. The development of triploid (sterile) fish could solve the problem of genetic damage caused by escaping farmed salmon, but it won't address the economic losses faced by a fish farmer whose valuable investment swims to freedom during a severe storm.[34]

2. Algae blooms

One important unsolved problem facing fish farmers is the threat of massive algae blooms that sometimes appear without warning. These massive growths can smother fish by removing oxygen from the water and can become toxic to the fish, either directly or indirectly through decomposition. These blooms are unpredictable and beyond the control of individual farmers. In most cases the algae blooms are the result of decades of agricultural run-offs, phosphates, and other pollutants entering the ocean. Given the right combination of water temperature, sunlight, currents, and nutrients, the explosive growth may occur. This has occurred off Norway in the past and has disrupted salmon farms. Four different species of algae have threatened Norwegian salmon farmers: *Chrysochromulina polylepis, C. leadbeatteri, Gyrodinium aureolum*, and *Prymnesium parvum*. The best recourse is to employ moveable pens that can be towed away from the advancing tide of algae. This problem is still an important threat to fish farmers as evidenced by the appearance of a bloom of *Chrysochromulina sp.* in northern Norway as late as June 1992. A similar outbreak in 1991 killed approximately 1,100 t of salmon worth about $2 million.[35] A Norwegian researcher has completed an experiment that might offer a partial solution to algae blooms in the future. The scientist raised 100 salmon at depths of 20 meters for a period of 42 days without the loss of a single fish; previously it was thought that it was impossible to raise salmon at such a depth.[36] Unfortunately, some algae blooms extend

down many meters and decaying algae will drop to the sea bed where it will rot, releasing poisonous substances for many, many kilometers.

3. Known diseases

Fish farmers around the world have suffered many serious outbreaks of different diseases during the past 2 decades. Contrary to popular belief, these diseases were generally caused by pathogens already existing in the natural environment. The stress caused by crowding typically reduces the fish's resistance to disease and enables the disease to spread quickly in the confined spaces of salmon pens. Thanks to pioneering work by scientists in many different freshwater and marine fields, many of today's diseases have been identified and remedies found. Thanks to these efforts, salmon farms have been reasonably free of disease in recent years. Strict government guidelines have also been enacted to keep disease from spreading when outbreaks occur and farmers realize the importance of treating diseases promptly to avoid massive losses throughout the industry.

Scottish salmon farmers faced problems with furunculosis (caused by *Aeromonas salmonocida*) in the mid-1980's. Strict enforcement action to stop this disease resulted in some bankruptcies and made it clear that sound management is necessary to prevent outbreaks of potentially very costly diseases. The Norwegian fish farming industry was impacted when they imported infected smolts from Scotland in 1985, one instance where a disease was directly attributable to farmed fish. Concern over the spread of disease has led officials of many nations to restrict or curtail imports of salmon eggs and smolts. In Iceland, which entered the salmon industry mainly as an exporter of smolts, the disappearance of foreign markets prompted smolt farmers to expand their operations into 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 and some salmon farmers in Norway, Scotland, and Canada now breed salmon in their own hatcheries as a means of preventing disease.

4. New Diseases

The "Hitra Disease" (a coldwater vibriosis caused by *Vibrio salmonocida*) broke out in Norway in 1985 and forced salmon farmers to destroy vast quantities of salmon and prematurely sell other fish in an attempt to control the disease.[37] Approximately 300 of Norway's 690 salmon farms were affected and losses reportedly reached 8,000 to 10,000 t worth $33 million.[38] This outbreak graphically demonstrated the importance of careful farm management and the need to enforce tough sanctions against infected farms. Eventually, Norwegian scientists were able to develop a highly effective vaccine which has brought this disease under control. Smolts that survived the disease retained their immunity and were used for broodstock. New outbreaks, however, are a serious possibility with potentially damaging consequences. A new disease, "salmon ricket poisoning," (caused by an unknown strain of the *Rickettsia bacterium*) has recently surfaced in Chile and is not responding to treatment. If Chilean scientists cannot control the disease, it may result in many Chilean salmon farms facing bankruptcy. Whether Chilean scientists can respond to the challenge remains uncertain. It is also unknown if Chilean salmon or their smolts will develop sufficient antibodies to the bacterium. Efforts to prevent the spread of the disease have imposed added restrictions and regulations on an industry faced with potentially massive losses. These regulations, unfortunately, must be draconian if they are to halt the spread of the disease. The long-term outlook, however, is generally optimistic. Marine biologists in Norway were able to respond within a few years to the "Hitra disease" and produced very effective vaccines to combat the disease within a few years.

There are other issues that must be considered in the establishment or operation of salmon farms. These include the salinity of the water (30 to 35‰), the water temperature of the area (5° to 15° C.), and where the facilities are to be anchored. The type of sea bed is important; mooring anchors in hard sand provides the best anchorage. Depth of water is important; cages should always be moored in water three times their depth. Fouling is a problem for netting. Badly fouled nets add stress to the structure and prevent a flow of water. Moreover, treating fouled nets can introduce chemicals into the environment. Irish researchers looking into the decline of sea trout in waters near salmon farms have identified a number of other sources of potential damage to water quality which includes: forestry operations, peat harvesting, quarrying, exploration and mining, drainage and gravel removal, silage-making, sheep dipping, aerial spraying of fertilizers, herbicides, and other chemicals, domestic and industrial pollution, and excessive grazing on mountain land (which causes erosion and silting).[39]

IV. TECHNOLOGICAL ADVANCES

A. General

Salmon farming is a major industry, generating hundreds of millions of dollars annually. Investments of many farmers are so great that it makes sense for these farmers to use new technology to remain competitive. The costs are frequently great, but both the risks and rewards justify the expense. In many cases it is the salmon farmer that must bear the cost. The State assists in the development process, either by supporting research institutes or by providing grants to modernize. In other instances, the State imposes legislation that requires farmers to make certain investments. In some cases, work in one area leads to multiple solutions. The work to develop sterile salmon, for example, reduces the need for farmers to harvest fish within 28 months of smoltification. At the same time, it resolves the issue of escaping salmon mating with wild stocks.

B. Applications

Many farmers utilize intensive farming methods, raising salmon under high-density conditions. Movable floating sea-cages, automated feeding equipment, and waste filtering systems are increasingly common. 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. Unless detected, a diseased fish can infect thousands of other fish. Modern technology allows the farmer to provide new solutions to deal with crowding and stress. One of the most elementary methods used by successful operations is to provide each tank with a carefully filtered stream of water and an outlet that prevents other tanks from being contaminated. In some instances, the issue of contamination is so intense that a visit to a smolt farm is similar to visiting a hospital operating room: stainless steel appliances are everywhere, and visitors are required to wear special boots, hats, and gowns, and to enter and leave the area through disinfectant tanks to remove any trace of pathogens.

Modern technology has even provided more "natural" remedies to problems. For example, Norwegian salmon biologists have developed nonmedical treatments for certain salmon diseases and maladies. The most successful example of these natural treatments is the use of "cleaner fish," and other natural methods, to remove salmon lice from farmed salmon. The ability of scientists to find "natural" solutions to these problems will provide salmon farmers with badly needed answers to face growing criticism from citizens living in the area around salmon farms. The use of chemicals to treat fish afflicted with salmon lice has produced considerable publicity in Scotland and Ireland. Opposition by public groups is so vocal in some places, notably in Ireland, that it has halted the development of the industry. Thus, natural solutions to the problem of sea lice could have an immediate benefit in some countries.

The most important technological advances, however, are still to come. Many of these advances are being developed as a method of eliminating current practices that impact on the environment. For example, improving the nutritional value of feedstuffs reduces the amount of feed that must be fed to fish (a significant cost savings), and also reduces the amount of excess feed and fish waste entering the aquatic environment. Scientists are working to breed salmon with a certain fat content and flesh color for consumers. The ability to influence the color of fish flesh is expected to become increasingly important in the future. The EC is very concerned about the use of artificial additives, and this concern is spreading to consumers and regulatory agencies around the world; the development of natural methods for influencing the coloration of salmon flesh will be increasingly important in the future. This type of research along with increasing automation and decreasing the impact of salmon farming operations on the environment are key concerns where technology can contribute important answers in the future.

It should be noted that technology is not always the solution to all problems. The development of huge, offshore salmon farms is a technological feat. However, they can produce significant difficulties if they fail during a severe storm. The release of millions of fish is not only an important genetic threat to the environment, but also poses a massive financial loss to farmers. The development or application of new chemical treatments in fish farming, such as the use of Ivomectin in Ireland, may also prove to be harmful in the long run; use of more "natural" methods could prove more beneficial.

V. WORLD HARVESTS

A. Overview

Fish farmers have raised rainbow trout for many years with considerable success. Once the problems of dual fresh and salt water life span were solved, Norwegian and Scottish fish farmers were able to take an early lead in the cultivation of Atlantic salmon. In 1970, there were 5 salmon farms in operation in Norway, and production had not yet reached 100 tons. By 1980, there were 173 Norwegian salmon farms in commercial operation and harvests exceeded 4,000 tons. Commercial salmon farming operations were also beginning in Scotland. Additionally, fish farmers in other nations were commencing salmon aquaculture programs based on the Norwegian model, although these were mostly limited to a few small experimental operations. World production, almost exclusively from Norway and Japan, amounted to only 7,000 t in 1980. The chief difficulties for aquaculturists were technical; farmers had to develop profitable methods of raising salmon while facing the danger that disease, predators, or storms could wipe out their entire stock. Many of these problems were overcome during the 1980s. The major problem for the 1990s will be to reestablish orderly marketing programs and to reestablish the image of salmon as a product deserving premium prices in markets around the world.

B. 1991 harvests

Commercial harvests of farmed Atlantic and Pacific salmon peaked at over 325,000 t in 1991 and are projected to decline to about 300,000 t in 1992. Atlantic salmon is the single most important cultured salmonid in the world. World harvests of Atlantic salmon increased from about 5,000 t in 1980 to over 260,000 t in 1991. The most important producers are Norway, Scotland, The Faroe Islands, Chile, Canada, and Ireland, which together account for over three-fourths of the world's harvest of Atlantic salmon. Japan, Chile, and Canada are the world's leaders in the harvest of cultured Pacific salmon species. The production of Pacific species increased from 2 t in 1980 to 65,000 t in 1991 (figure 2).

In 1991, the leading producers of farmed salmon included: **Norway** (154,000 t), **Scotland** (41,000 t), **Chile** (34,000 t), **Canada** (27,000 t), **Japan** (27,000 t), the **Faroe Islands** (16,000 t), **Ireland** (9,000 t), **the United States** (7,000 t), **Iceland** (3,000 t), **Australia** (2,700 t), and **New Zealand** (2,000 t). Small farms are operating in a number of other countries including **France** (1,400 t), **Sweden** (700 t), **Spain** (500 t) and **Finland** (100 t). **Turkey** and **Korea** have started raising salmon in the last year or two. It is possible that salmon farming could become an important new business in **Russia** (figure 3).

The Norwegian salmon harvest should decline to about 120,000 t in 1992, a decrease of about 34,000 tons. Many other producing nations, however, will probably increase their harvests. The world harvest should be over 300,000 t in 1992.

VI. SALMON PRODUCTS

Once the fish is harvested, it is prepared for sale to consumers or to processors for additional refinements. Salmon has been a popular food for hundreds of years and is generally preferred fresh or smoked. Frozen salmon and other new products are being developed and will appear increasingly in restaurants and seafood stores around the world.

A. Fresh

After removal from the pens, a vein in the salmon's gills is severed with a short, swift cut. The fish is immediately placed into a covered vat where it is allowed to bleed. In some facilities carbon dioxide is used to quiet the fish during its final moments. The flushing of the blood produces a higher flesh quality and is a painless method of killing the fish. After death the fish is gutted and the intestines frozen for sale to mink farmers. The gutted fish is carefully washed and then placed into a vat of icy water to reduce its body temperature. The chilled salmon is placed on a conveyor belt that automatically separates each fish by weight. The fish are then carefully packed into a lightweight, waterproof container and surrounded by finely crushed ice. In many countries a "gill tag" is clipped onto the gill to designate the country of origin and the quality of the product. The container is filled with salmon and ice, closed, weighed, and marked for shipment. Fresh fish is usually sent to near-by airports for shipment to central shipping facilities; it

Figure 2.--World harvest of Atlantic and Pacific salmon, by species, 1980-1991.

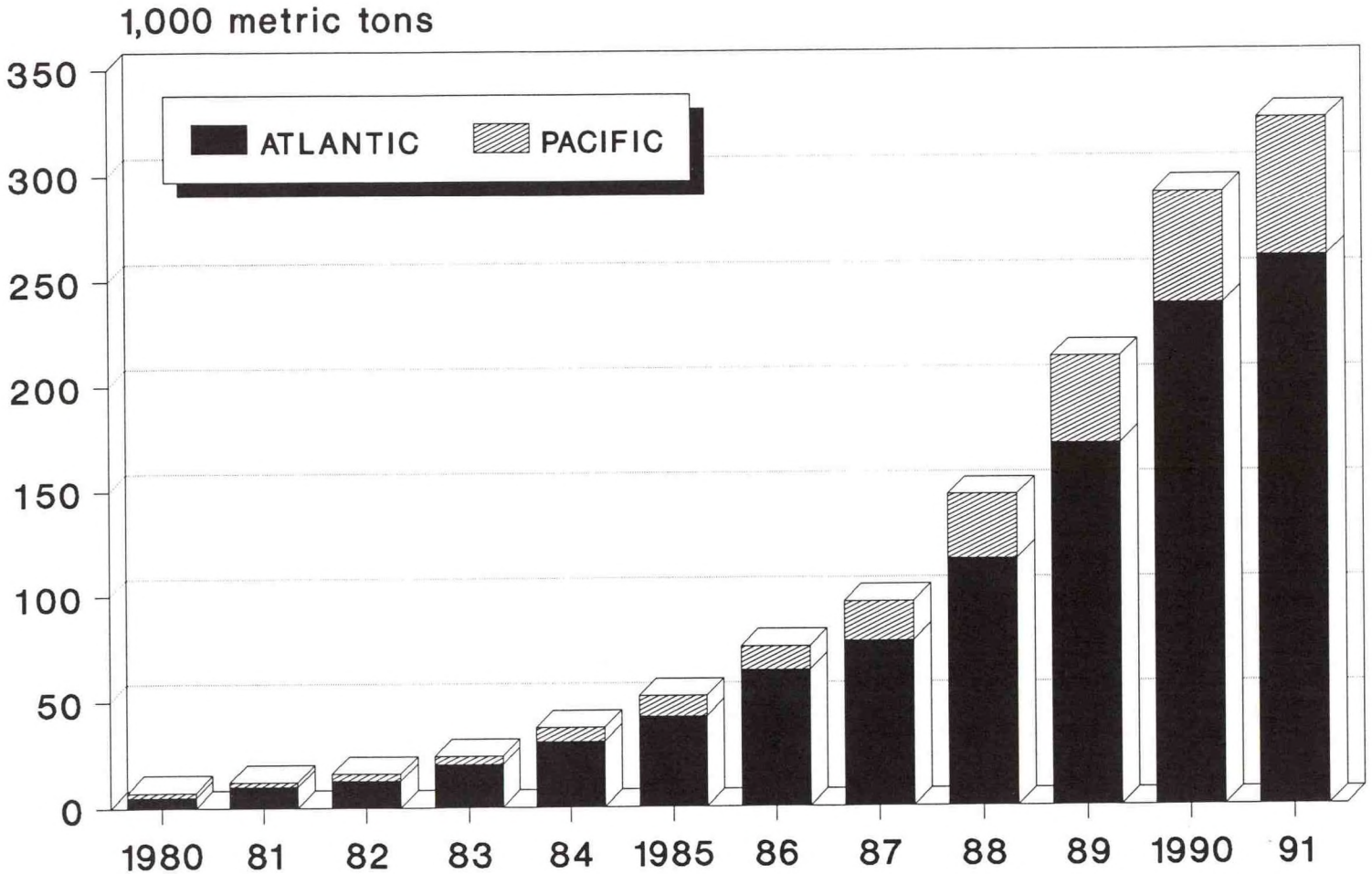


Figure 3.--World harvest of farmed salmon, by country, 1980-91.

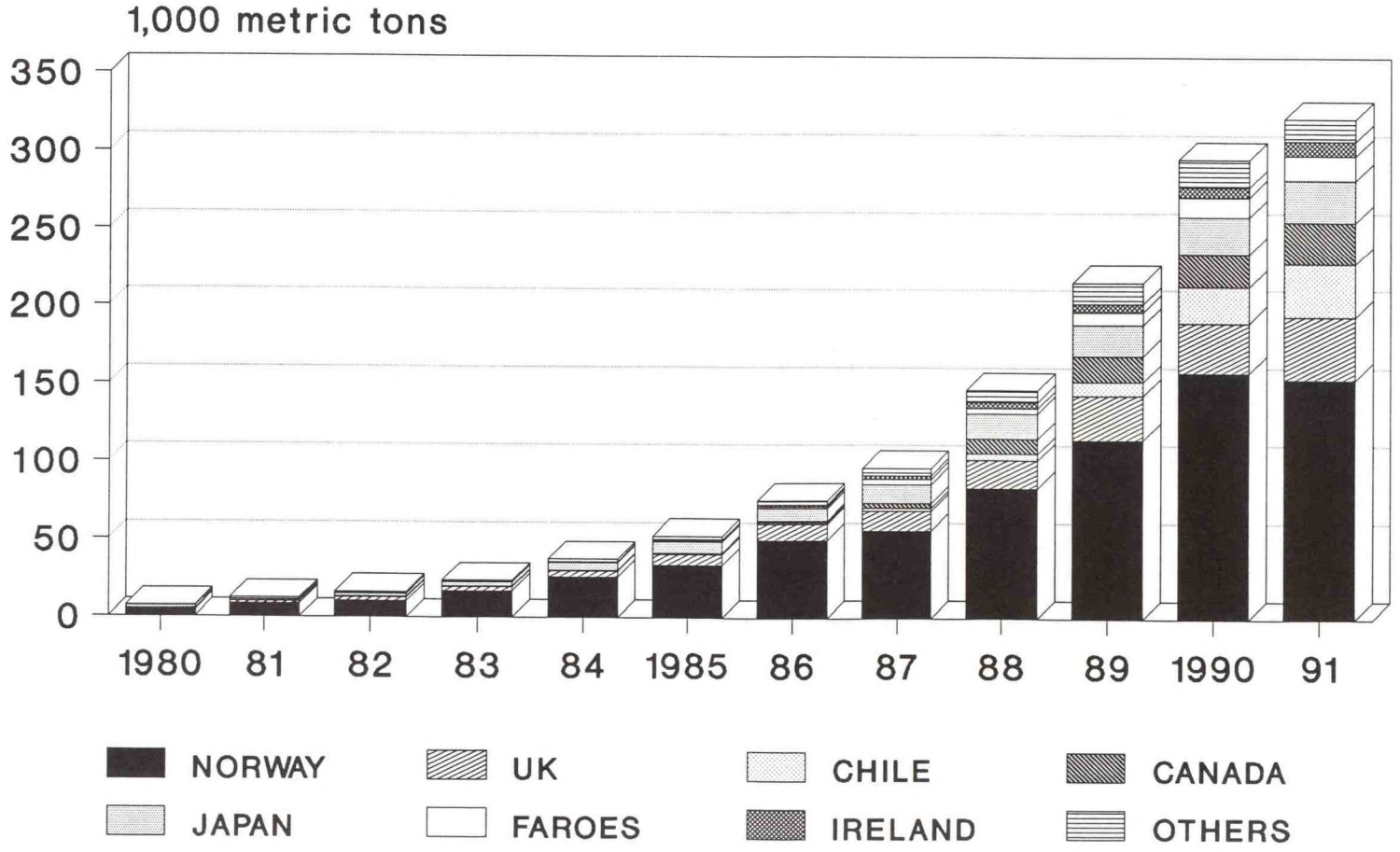
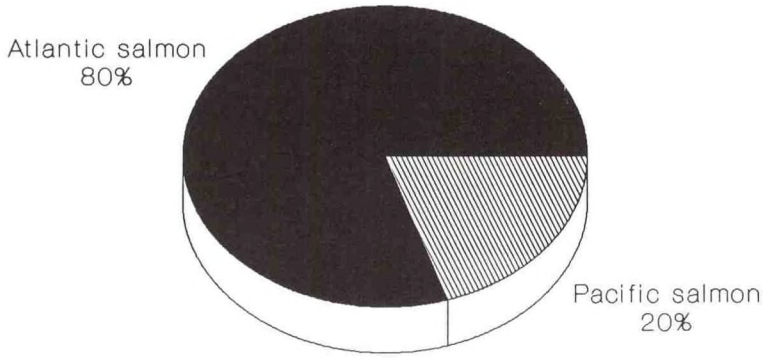
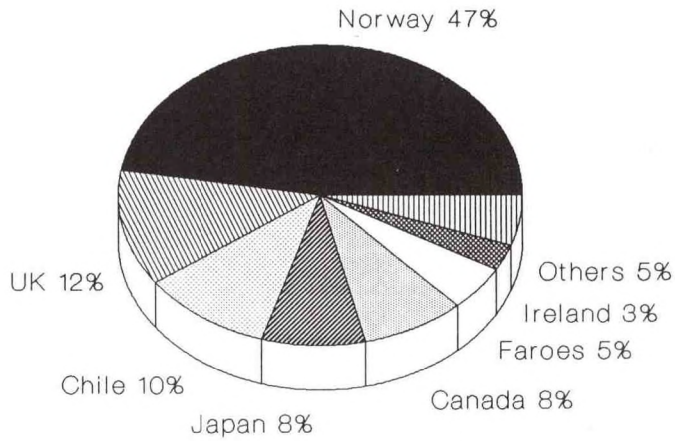


Figure 4.--World harvest of farmed salmon, by species, 1991.



1991 HARVEST

Figure 5.--World harvest of farmed salmon, by country, 1991.



1991 HARVEST

is usually airfreighted to overseas markets within hours of harvest.

Fresh fish is quickly distributed upon arrival. Many fish go immediately to restaurants, where they are featured in elegant "white tablecloth" settings. Others are shipped to specialty fish shops or to grocery stores, where they can be sold to consumers as fillets, steaks, or as "pan-sized" products. Most of the world's production of salmon is currently sold as "fresh" product.

B. Frozen

Producers also sell frozen salmon and salmon products. Seafood producers are increasingly buying salmon for use in frozen seafood entrees. Frozen pan-sized salmon can be purchased at many grocery stores for home preparation. Portion-sized frozen fillets or steaks with sauces or other ingredients are becoming increasingly popular at home and in many restaurants.

Norwegian salmon farmers were recently forced to freeze large quantities of salmon as harvests exceeded demand. This ultimately generated a "mountain" of over 37,000 t of frozen salmon. Consumers, fortunately, responded favorably to the frozen salmon, and it now appears that frozen, whole salmon might also be an important export commodity for Norwegian exporters. The Norwegian salmon "mountain" was eventually sold to a number of new clients; this was part of the program to reduce the supply of frozen salmon without disrupting established markets. Little information is available on the destination of these frozen salmon sales, but new consumers have had an opportunity to sample Norwegian salmon which might also result in new markets. It is possible that a second-quality market might be developed for some whole, frozen products in the future.

C. Other

Scottish-smoked salmon has long been associated with some of the finest seafood products ever produced. This is the result of generations of smokers producing a high quality product from the wild salmon that once came ashore by the hundreds of thousands. Today, smokers in Scotland, Denmark, Ireland, and elsewhere rely on salmon farmers to supply them with salmon on a regular basis. Improvements in the quality of smoked salmon have quickly followed and further improvements can be anticipated. Careful attention to fat content, for example, is an important part of the smoking process, and salmon can be harvested at just the right time to meet this demand.

***Figure 6.**--Salmon are quickly processed for shipment to customers within hours of harvest.*

The marketing problems caused by Norway's salmon harvests between 1989 and 1991 demonstrated the weakness of having only a few marketable products. Thus, a number of seafood producers are developing new product forms. A new salmon pate, for example, was developed by the Norwegians and is being sold in 250-gram cans in Norway. Other products are certain to follow. Developing value-added products is an important long-term goal for many countries interested in the European market. The problem, however, is high EC tariffs on imported value-added products. These import duties can add 15 percent or more to the price of finished seafood products.

VII. WORLD MARKETS

A. Increasing harvests, 1989-91

Early in the decade, farmed salmon was a rarity and was priced as a luxury food. Rapid advances in farmed salmon production created new difficulties, however. Norway, the world's largest producer, harvested so much farmed salmon in 1989 that exporters were unable to maintain an orderly distribution of the product and prices began to decline. The Norwegian Salmon Farmers Sales Organization (FOS) began freezing significant quantities of salmon in early 1990, in an attempt to siphon off excess salmon and protect the huge Norwegian industry by stabilizing fresh salmon prices. The action, however, failed to halt the flood of products entering the market and prices continued to decline. The United States initiated anti-dumping and countervailing duties on imported Norwegian salmon in 1990-91; this had a significant impact on Norway's exports to the United States and added to the growing inventories of unsold salmon. The FOS filed for bankruptcy in late 1991, after failing to dispose of the "mountain" of unsold frozen salmon. The Norwegian position was further complicated when the European Community imposed a minimum import price for salmon in late 1991. The outlook for Norway is a reduction in harvests of about 30,000 t in 1992.

B. Lower prices

Farmed salmon prices declined gradually during most of the 1980s as farmed salmon supplies increased. During 1989 supplies of farmed salmon surged, and prices decreased sharply. This was a major concern for salmon producers around the world. Scottish, Irish, and U. S. producers alleged that Norwegian salmon farmers were selling fresh salmon below the cost of production, or "dumping," in world markets. The decline in salmon prices disrupted a profitable growth industry from New Zealand to Norway. For salmon farmers in other countries, many of them still paying high start-up costs, falling prices posed a more serious threat. The decline in prices for fresh-chilled Norwegian salmon at the Rungis wholesale market in Paris, France provides graphic evidence of the decline (figure 7). The declining trend in these prices is clearly evident (figure 8).

C. Outlook for 1992

The short-term outlook for Norway remains uncertain. Norwegian salmon farmers were selling their salmon at very low prices in early 1992, trying to generate enough cash to maintain their operations. Norwegian salmon farmers hope that the situation will improve towards the end of 1992 when prices increase during the traditional holiday season. The current projection for Norway's 1992 harvest of farmed salmon is 120,000 tons.

Ireland and the United Kingdom (Scotland) anticipate possible shortages of farmed salmon in 1992, mostly as a result of the economic dislocations still taking place in Norway. In addition, the European Community has begun to impose new uniform standards for the seafood processing industries seeking to sell inside the EC. As member nations, both Ireland and the UK have received funding to assist their industries in complying with tough standards that are being imposed. This should allow both the Irish and Scottish salmon producers to further establish their place in the EC market. The outlook for both the UK and Ireland is for continued growth.

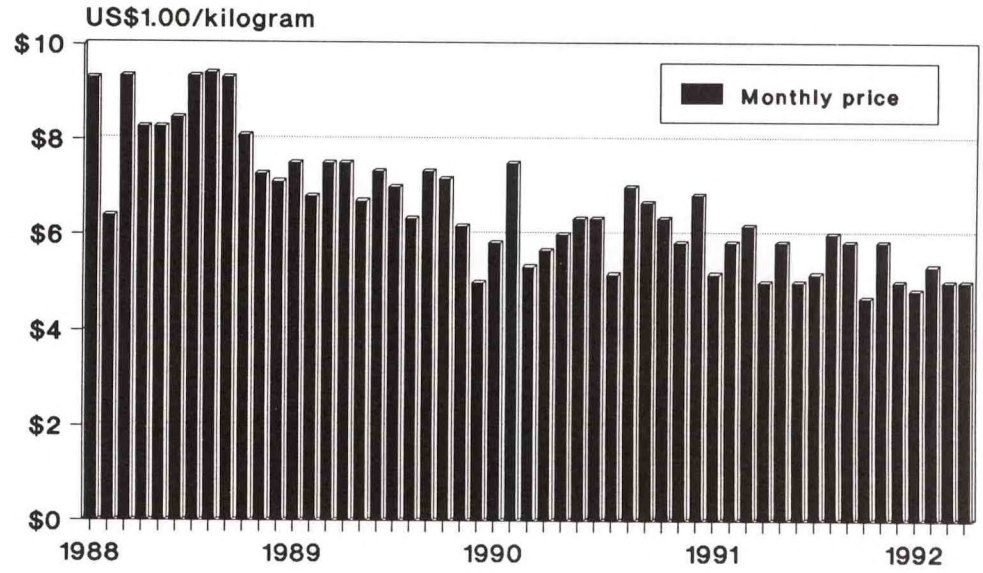
Salmon farmers in the Faroe Islands, although suffering economic dislocation, expect to expand their production and marketing efforts. The Faroe Islands anticipate strong sales to Denmark, and production is expected to increase. The situation in Iceland, unfortunately, is less certain. The industry has been badly decimated, and it may be difficult for them to recover. Iceland's withdrawal from the International Whaling Commission (IWC) and the planned resumption of commercial whaling may trigger consumer boycotts of Icelandic exports; this would further damage the salmon industry.

Chile and Canada expect to profit from the U.S. economic sanctions against Norway by expanding their sales in the enormous U.S. market. Salmon growers in Australia, Chile, and New Zealand are also working to develop markets in Japan. Barring any unforeseen events, such as a dramatic loss of Chilean salmon to disease, world harvests should remain over 300,000 metric tons.

D. Long-range forecast

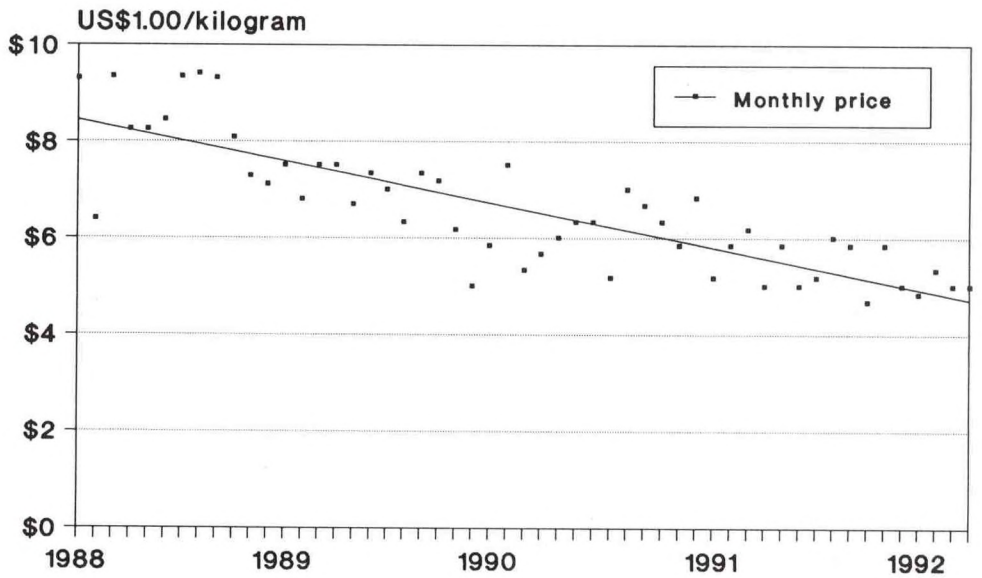
Observers expect the Norwegian industry to recover in the next few years. The highly resourceful Norwegians will not be kept away from world markets for long. Certainly the Norwegians

Figure 7.--Monthly wholesale prices for fresh Norwegian salmon at the Rungis market in Paris, 1988-92.



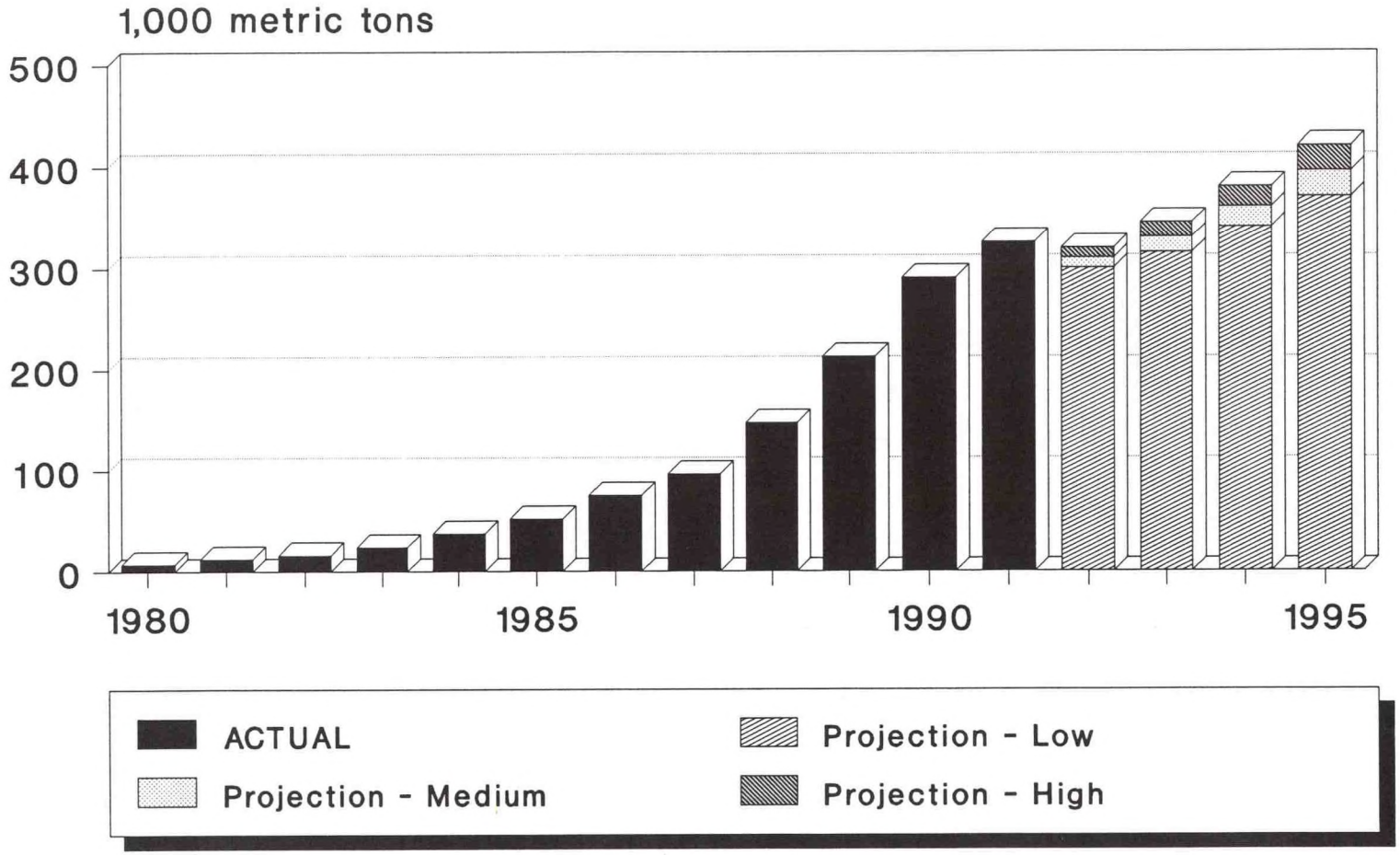
Source: INFOFISH Trade News.

Figure 8.--Trendline of monthly prices for fresh Norwegian salmon at the Rungis market in Paris, 1988-92.



Source: INFOFISH Trade News.

Figure 9.--World farmed salmon harvests, projected to 1995.



will develop new products and resume aggressive marketing programs to regain lost markets. If the Norwegians are able to maintain their export prices to the EC, then there should be no problem with new minimum import prices or other tariffs. The threat does remain, however, and the EC has clearly stated that they will not hesitate to employ trade sanctions if necessary. The Norwegians can also be expected to seek legal remedies to the anti-dumping and subsidy tariffs imposed by the United States. If successful, they will be able to re-enter the U.S. market. If they are not successful, they will doubtlessly look to develop markets for a variety of frozen, value-added salmon products. One important unknown factor involves the recent decision by Norway to resume whaling. This announcement, made during the July 1992 meeting of the IWC, could also result in consumer boycotts of Norwegian seafood. Since Norwegian salmon faces stiff U.S. tariffs, a boycott would not significantly impact sales to the United States, but it could damage Norwegian exports to the EC if European consumers protest the whaling decision.

Chile and Canada both took advantage of the Norwegian's trade problems with the United States to gain a firm position in the U.S. market. Chile and Canada are now the main suppliers of farmed salmon to the United States. Other nations took advantage of the "breathing space" to consolidate their industries (sometimes painfully) and are now in a better position to expand their markets. The long term outlook for world farmed salmon production is excellent, and output should begin to approach the 400,000 t mark before the turn of the century (figure 9).

VIII. OCEAN 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 1990s. 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 increases the existing wild salmon populations, accounts for most of Japan's 150,000 t annual catch of chum salmon. Other nations, including Iceland, have also engaged in this kind of salmon ranching. The 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 ability 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: (1) production costs could be quite low, since salmon are raised at sea, and (2) ranchers may be able to promote their product as being indistinguishable from pure wild salmon.

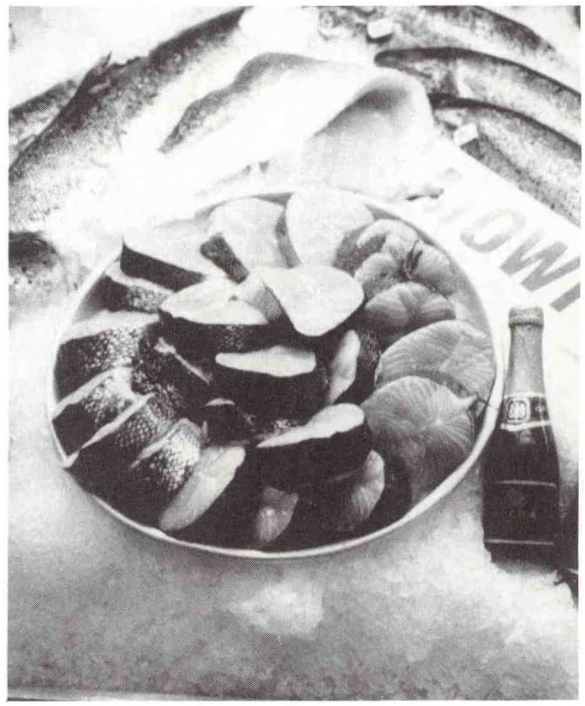


Figure 10.--Fresh salmon awaits customers in markets around the world.

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ENDNOTES

INTRODUCTION

1. The value of the harvest was determine by multiplying 260,000 tons of Atlantic salmon by $5.00 per kilogram and 65,000 tons of Pacific species by $3.00 per kilogram to arrive at a general value figure for total world production. The actual value, naturally, will vary considerably.

SECTION I (Historic Overview)

2. Lauren R. Donaldson and Timothy Joyner, "The Salmonid Fishes as a Natural Livestock," *Scientific American*, Vol. 249, No. 1., July 1983, p.53.

3. Dennis Weidner, *British Salmon Industry, 1983-84,* International Fishery Report (IFR-84/100), National Marine Fisheries Service, NOAA, U.S. Department of Commerce.

4. *Salmon Farming: Building Ireland's Newest Marine Industry*, a cooperative publication of the Irish Salmon Growers Association and the An Board Iascaigh Mhara, Dublin, (no date).

5. Lauren R. Donaldson and Timothy Joyner, "The Salmonid Fishes as a Natural Livestock," *Scientific American*, *op. cit.*, 1983, p.53.

6. Rainbow trout (*Salmo gairdneri)* are usually associated with freshwater in both their wild and cultured state. The rainbow trout can be raised in a saltwater environment where they are usually called "steelhead trout". The steelhead trout was recently reclassified as "*Oncorhynchus mykiss*" and is now considered a distinct salmon species. Rainbow trout cultivation is quite common in many nations. This report does not, however, consider the cultivation of rainbow trout.

7. Stephen Drummond Sedgwick, *Salmon Farming Handbook*, Fishing News Books, Ltd., Farnham, Surrey, England, 1988, p.9.

8. Stephen Drummond Sedgwick, Salmon Farming Handbook, *op.cit.*, pp.9-10.

9. *Ibid*

10. *Ibid*

SECTION II (Biology)

11. The seventh salmon is the steelhead trout, which was reclassified as *Oncorhynchus mykiss* in 1989. This report does not examine the farming of steelhead (or "rainbow") trout, which is an important farm-raised fish in many parts of the world.

12. Steelhead is not considered in this report.

13. Except for steelhead trout which is now classified as a Pacific salmon.

14. Atlantic salmon that return after only 1 year at sea are called "grilse" and usually weight 1.5 to 2.5 kilograms. In the wild, the grilse account for about 30 percent of all smolts. Pacific salmon can spend 1 to 5 years at sea before returning to spawn, depending on the species.

15. These traits include fast growth, a desired level of fat content, flesh color, muscle tone, resistance to diseases, etc. Original broodstock are based on wild specimens and then carefully husbanded for several generations before being replaced. Broodstock are also selected from specific year classes that demonstrate special traits. Smolts that survived exposure to furunculosis in Norway, for example, were selected as broodstock when they reached maturity. Eventually it is helpful to re-introduce wild stocks to the captive breeding stock to prevent inbreeding and to maintain genetic diversity.

16. The physical, metabolic, and other changes associated with smoltification are very complex and are well documented by Laird Lindsay and Ted Needham, in "Sea Water Culture of Salmonids," *Aquaculture*, Volume 2, Ellis Horwood Ltd, West Sussex, England, 1990, p. 629.

17. Laird Lindsay and Ted Needham, "Sea Water Culture of Salmonids," *Aquaculture*, Volume 2, Ellis Horwood Ltd, West Sussex, England, 1990,p.629.

18. "Market-size" varies according to the species being raised and is based on the requirement of processors (such as smokers), and consumer preferences. Some salmon are harvested when they are still quite small (pan-sized), while others are grown to 5 kilograms or more.

19. Sexual maturation in salmon involves the utilization of body fats, protein, and carbohydrates to create eggs and milt. These fats also contain concentrations of carotenoid which provide the salmon's characteristic pink or red color. As the salmon's nutrients are depleted to produce roe or milt, the flesh becomes pale, watery, and tasteless. See: Stephen Drummond Sedgwick, *Salmon Farming Handbook.* Fishing News Books Ltd., Farnham, Surrey, England, 1988. p. 22-23.

20. Trond Bjørndal, *Industrial Structure and Cost of Production in the Norwegian Aquaculture Industry*, Fundacion Chile, Santiago, Chile, March 17-19, 1987, pp. 2-3.

SECTION III (Problems of Salmon Culture)

21. All aspects of fish farming, good or bad, should be taken into consideration in making a judgement to support or deny a request for a license to begin a salmon farming operation.

22. The Sea Trout Action Group, or STAG (set up to investigate the problem with sea trout) recently accused the Killary Salmon farm of infecting wild stocks of sea trout with sea lice in the area around Delphi and Erriff in western Ireland. The STAG claimed that 94 percent of sea lice in the area originated from salmon farms. The Irish Salmon Growers' Association (ISGA), however, proved that the Killary Salmon farm did not contain any smolts or salmon during the migration of the sea trout into the area. All salmon introduced by the Killary Salmon farm since then were completely free of salmon lice. "Irish Fish Farmers Deny Infecting Sea Trout," *Eurofish Report*, June 18, 1992, p. FS/3.

23. Duane Kelly, "Salmon Farming, Norwegian Style," *Pacific Fishing*, November 1984, p.54.

24. The use of shrimp offal by the salmon farming industry is very beneficial to Norway's shrimp industry, since 70 to 75 percent of the landed weight of shrimp consists of waste products (i.e., the head and shell). James R. Brooker, *Report on Aquaculture Activities in Norway*, National Marine Fisheries Service, NOAA, U.S. Department of Commerce, Washington, D.C., July 1984.

25. Dr. Trond Storebakken, Senior Scientist (Nutrition) at the Institute of Aquaculture Research, at Sunndalsøra, discussed recent developments in salmon nutrition during a visit to the AKVAFORSK research station. See also: "Bright Future is Seen for Salmon Farms, Feeds and Feeding, *Fish Farming International*, March 1980, p.14.

26. British scientists have discovered that triploidy in salmon eggs can be induced by three methods: high hydrostatic pressure, heat-shock, and anaesthetic chemicals. The high hydrostatic pressure method has proven the most reliable. Scottish scientists have produced over 1 million triploidised salmon eggs between 1986 and

1989. The Aberdeen university Marine Studies Ltd., Department of Zoology, in Aberdeen even advertises the fact that it provides a service for the triploidisation of salmon eggs. Dr. Ted Needham, "A New Service to Control Grilsing in Scottish Salmon," *Fish Farmer*, November/December 1989, pp.45-46.

27. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, in a fax message dated July 20, 1992.

28. Norsk Fiskeoppdrett, No. 6/91, p. 49 and Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, in a fax message dated July 20, 1992.

29. Boxaspen, Karin. *PYRETRUM - Et naturlig insekticid og mulig middel mot lakselus*, Havforskningsinstitutte, Senter for Havbruk, Bergen, November 1990.

30. NORINFORM, January 23, 1990.

31. *Fish Farming International*, July 1991.

32. Personal discussions with scientists at the Institute of Aquaculture Research in Sunndalsøra on May 13, 1992.

33. Norwegian salmon farmers lost large numbers of salmon when the storm destroyed nets and cages. In addition to the economic effects the losses had on an already ailing salmon aquaculture industry, the lost farmed stock pose a threat to the genetic integrity of Norwegian wild salmon stocks. Ecologists are concerned, because farm breeding causes certain noticeable defects in salmon (such as shorter lower jaws and abnormal fin development) which could damage the gene pool of wild populations. For more information, see *Seafood International*, March 1992, or NORINFORM publications from January - March, 1992.

34. Consumer concerns about genetic tampering with salmon is an important problem and has halted such experiments in Norway. The Norwegian Fish Farmers Association is strongly opposed to genetic manipulation of any salmon (or other fish or shellfish) destined for human consumption. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, in a fax message dated July 20, 1992.

35. "Algae Invasion in Norway," *Eurofish Report*, June 18, 1992 and personal discussions with Birger Larsen, Norwegian Fisheries Attache in Washington, D.C.

36. "Farming Salmon Under Water," *Eurofish Report*, June 18, 1992.

37. Hitra disease is in fact named for the island where the first serious outbreak of this disease occurred during 1985. The disease was first documented in northern Norway during 1980.

38. The Norwegian Fish Farmers Association reported the figure as 200 million NOK in their publication entitled *The Norwegian fish farming industry in harmony with the environment.*

39. Lorna Siggins, "Sea Lice May Not be only Factor In Trout Decline, Say Scientists," *Irish Times*, August 6, 1990.

Appendix A

Table 1.--World farmed salmon harvests, by country, 1980-91.

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
EUROPE:						*Metric Tons*						
Faroe Islands	0	0	60	105	116	470	1,370	3,533	3,300	8,300	13,000	16,000e
Finland	0	30	30	30	94	100	100	127	150	170	100	100
France	30	40	80	80	50	60	60	250	120e	135e	1,240e	1,430e
Iceland	5	20	30	50	107	91	123	530	1,233	3,900	3,500	3,030
Ireland	21	35	100	257	385	700	1,215	2,232	4,075	5,196	6,323	9,300
Norway	4,143	8,422	10,266	17,000	25,936	33,796	49,985	56,204	83,700	114,866	157,944	154,000
Spain	0	0	0	0	100	150	150	150	150	150	355	553
Sweden	0	0	10	15	59	81	160	224	749	1,110	1,114	732
Turkey	0	0	0	0	0	0	0	0	0	0	0	0
U.K.(Scotland)	598	1,333	2,152	2,536	3,912	6,921	10,337	12,721	17,951	28,553	32,350	40,593
Sub-total	4,797	9,880	12,728	20,073	30,759	42,369	63,500	75,971	111,428	162,380	215,926	225,738
NORTH AND SOUTH AMERICA:												
Canada	168	197	311	196	330	470	1,038	3,129	9,805	16,750	21,167	26,979
Chile	0	1	184	94	109	500	1,144	1,821	4,208	8,804	23,329	34,075
U.S.A.	329	873	691	907	1,153	1,596	1,293	2,438	4,209	3,554	3,892	7,121
Sub-total	497	1,071	1,186	1,197	1,592	2,566	3,475	7,388	18,222	29,108	48,388	68,175
PACIFIC:												
Australia	0	0	0	0	0	0	0	50	250	380	1,750	2,650
Japan	1,855	1,159	2,122	2,760	5,049	6,990	7,850	12,170	16,300	19,975	24,000	27,000
New Zealand	0	2	5	10	10	250	600	900	1,150	1,150	1,200	2,000
Russia	0	0	0	0	0	0	-	5	10	11	-	-
South Korea	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total	1,855	1,161	2,127	2,770	5,059	7,240	8,450	13,125	17,710	21,516	26,950	31,650
TOTAL	7,149	12,112	16,041	24,040	37,410	52,175	75,425	96,484	147,360	213,004	291,264	325,563

Sources: U.S. Diplomatic posts reporting in 1992. *Aquaculture*, Food and Agriculture Organization of the United Nations, FAO Circular 815, various years (data for Russian salmon production betwen 1985 and 1989). Chilean production was obtained from Servicio Nacional de Pesca, *Anuario Estadistico de Pesca.*

N.A. = not available. - = negligible. e = estimate.

Table 2.–World farmed salmon harvests, by species, 1980-91.

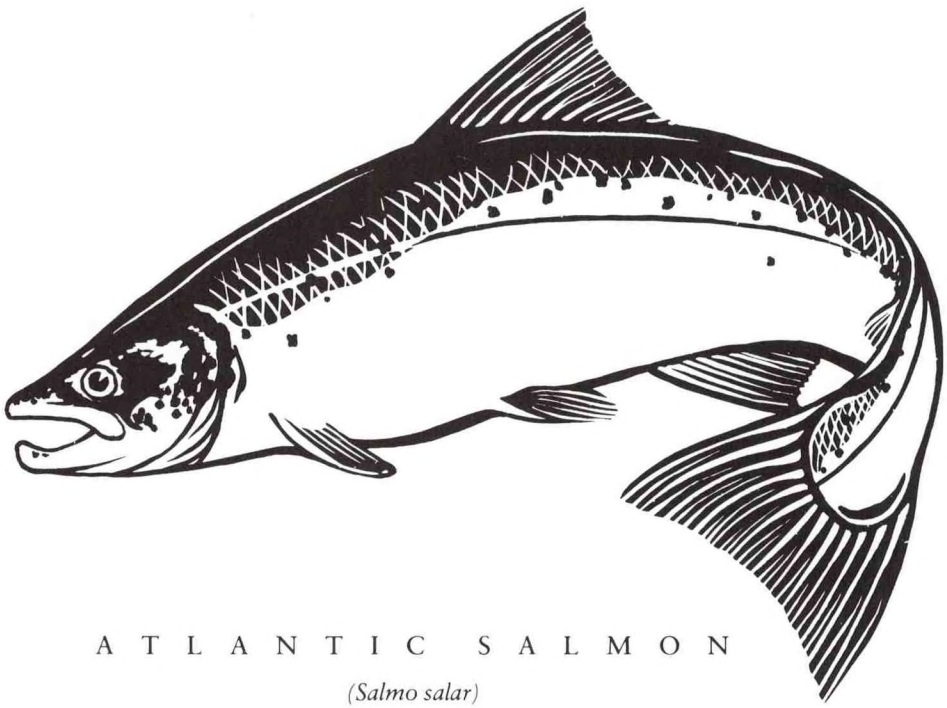
Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
ATLANTIC SALMON:						*Metric Tons*						
Australia	0	0	0	0	0	0	0	50	250	380	1,750	2,650
Canada	11	21	38	68	223	350	647	1,390	3,480	5,680	9,475	12,523
Chile	0	0	0	0	0	0	0	41	165	1,860	9,498	14,957
Faroe Islands	0	0	60	105	116	470	1,370	3,533	3,300	8,300	13,000	16,000e
Finland	0	30	30	30	94	100	100	127	150	170	100	100
France	0	0	0	0	0	0	0	0	60	85	1,200	1,400
Iceland	5	20	30	50	107	91	123	530	1,233	3,900	3,500	3,030
Ireland	21	35	100	257	385	700	1,215	2,232	4,075	5,196	6,323	9,300
Norway	4,143	8,422	10,266	17,000	25,936	33,796	49,985	56,204	83,700	114,866	157,944	154,000
Spain	0	0	0	0	0	0	0	0	0	0	205	403
Sweden	0	0	10	15	59	81	160	224	749	1,110	1,114	732
Turkey	0	0	0	0	0	0	0	0	0	0	0	0
U.K. (Scotland)	598	1,333	2,152	2,536	3,912	6,921	10,337	12,721	17,951	28,553	32,350	40,593
U.S.A.	0	0	0	0	23	68	136	800	1,700	1,539	2,082	4,704
Sub-total	4,778	9,861	12,686	20,061	30,855	42,577	64,073	77,852	116,813	171,639	238,541	260,392
PACIFIC SALMON:												
France	30	40	80	80	50	60	60	250	60e	50e	40e	30e
Canada	157	176	273	128	107	120	391	1,739	6,325	11,070	11,692	14,456
Chile	0	1	184	94	109	500	1,144	1,780	4,043	6,944	13,831	19,118
Japan	1,855	1,159	2,122	2,760	5,049	6,990	7,850	12,170	16,300	19,975	24,000	27,000
New Zealand	0	2	5	10	10	250	600	900	1,150	1,150	1,200	2,000
Russia	0	0	0	0	0	0	0	5	10	11	0	0
Spain	0	0	0	0	100	150	150	150	150	150	150	150
South Korea	0	0	0	0	0	0	0	0	0	0	0	0
U.S.A.	329	873	691	907	1,130	1,528	1,157	1,638	2,509	2,015	1,810	2,417
Sub-total	2,371	2,251	3,355	3,979	6,555	9,598	11,352	18,632	30,547	41,365	52,723	65,171
TOTAL	7,149	12,112	16,041	24,040	37,410	52,175	75,425	96,484	147,360	213,004	291,264	325,563

Sources: U.S. Diplomatic posts, 1992. *Aquaculture,*, FAO Circular 815, various years (Russia 1985-89). Servicio Nacional de Pesca, *Anuario Estadistico de Pesca (for Chile)*. N.A. = not available. - = negligible. e = estimate.

COUNTRY REPORTS

Chapter IX

Western Europe



A T L A N T I C S A L M O N

(Salmo salar)

Artwork courtesy of the Association of Chilean Salmon Farmers

Chapter IX
Western Europe

FAROE ISLANDS

The Faroes are a chain of 18 islands situated between Iceland and Scotland. The Faroe Islands are a self-governing region of the Kingdom of Denmark. Though Denmark itself has no salmon culture, the Faroes rank among the world's ten largest producers of farmed Atlantic salmon.[1] Commercial salmon culture in the Faroes began when salmon farmers harvested 60 t of farmed salmon in 1982. The Faroese expanded their production to around 16,000 t in 1991.[2]

CONTENTS

I. GENERAL

A. Overview

Salmon farming is very important to the Faroese economy, accounting for about one-fifth (almost $89 million) of all Faroese exports. Because very little Faroese territory is suitable for agriculture, and even grazing land is scarce, the economy is fully dependent on fishing and fish processing. Fish farming constitutes a good supplement to Faroese fisheries, especially since many traditional fish species caught by Faroese fishermen have begun to decline (because of overfishing and biological fluctuations). Unit costs for producing farmed salmon are relatively high in the Faroes. This means that smaller Faroese farmers have suffered heavy losses following the precipitous decline in world salmon prices that began in 1989. This, in turn, has adversely impacted Faroese export earnings. Faroese salmon farmers are currently reorganizing their industry following several bankruptcies, and some industry analysts expect that the number of salmon farms operating today will be reduced by half before 1995. However, present production capacity is expected to remain almost unchanged.[3]

B. Problems

Faroese farmed salmon have suffered outbreaks of "whirling disease" (probably infectious pancreatic necrosis) in recent years. During the summer of 1988, an algae bloom appeared in some fjords. During the winter of 1988-89, a storm with winds of more than 150 miles per hour hit the islands. Several offshore sites suffered total losses of equipment and stock.[4] Faroese farmers must contend with the fact that offshore salmon production is more profitable and less strictly regulated, but also poses a higher risk of storm losses.[5]

II. HARVESTS

A. Smolts

During the early 1980s, all smolts used by Faroese salmon farmers were supplied by the government-owned P/f Fiskaaling research station. Fiskaaling's stock of broodfish came from Norwegian smolts imported during 1978, because local smolts taken from Faroese rivers failed to grow and reproduce in captivity. Two private smolt farms also began operation in 1983-84. The Faroese government, however, banned imports of foreign smolts to protect native salmon stocks from disease and importation of smolts remains illegal in the Faroe Islands. Faroese smolt farmers increased operations to 15 separate smolt farms by 1992, and smolts were actually oversupplied to the domestic market. Because the export market for smolts has also disappeared following the boom of the 1980s and bust of the 1990s, this leaves Faroese smolt farmers no choice but to decrease production during 1992 and 1993.[6]

B. Salmon

Faroese salmon farmers produce around 16,000 t of salmon per year. Tonnage per operator is quite high, partially due to highly mechanized production, and partially due to the large average size of each fish.[7] The most efficient farms are located in the narrow straits between the islands in very large floating fish farms.[8] These farms are expensive to purchase and are vulnerable to very bad weather, but are much more efficient than smaller, inshore farms. The Faroese salmon farming industry appears to be reasonably healthy: the Faroese are among the world's top producers of farmed salmon. This accomplishment is significant in view of the high costs of production in these remote northern islands.

III. COMPANIES

There were 15 hatcheries and 63 salmon grow-out farms operating in the Faroe Islands in 1990. The Faroe Islands are not members of the European Community and thus do not receive EC grants and funds for aquaculture. The Faroese Government does not provide funding for aquaculture (though it was instrumental in providing the startup technology and capital to begin the industry) and capital is in short supply. Five farms declared bankruptcy during 1990, and four more went bankrupt during 1991, leaving only 54 Faroese salmon farmers to begin the 1992 season. The high cost of skilled labor in the Faroes makes automation very cost effective, and the viable operators use highly automated, large capacity sites.[9] The Faroese Salmon Farmers Association (FSFA) is the representative of the industry.

IV. EXPORTS

Faroese salmon farmers exported 11,800 t of farmed salmon in 1990 out of a total harvest of 13,000 tons, or 91 percent of total harvests. Faroese farmed salmon exporters sold 15,600 t of salmon on foreign markets during 1991, bringing in an estimated $86 million in export earnings.[10] Salmon exports accounted for almost 98 percent of the total Faroese harvest during 1991. Salmon exports account for close to one-tenth of the Faroese Gross Domestic Product (GDP). The decline in world farmed salmon prices between 1989 and 1991 adversely impacted Faroese export earnings and hurt the Faroese economy. During 1991, for example, salmon exports increased 32 percent in quantity, but only 18.5 percent in value.[11] Faroese salmon is entirely directed at export markets.

Denmark is Faroese salmon exporters' most important customer. Faroese salmon farmers exported over 6,400 t of farmed salmon to Denmark during 1991, or nearly 40 percent of the Faroes' total farmed salmon exports. Denmark's processors smoke and reexport almost all of these imports, mostly to the lucrative French and German markets. Faroese farmed Atlantic salmon competes with Norwegian farmed Atlantic salmon. The Norwegian industry, however, is enormous and constitutes an overwhelming majority of world farmed Atlantic salmon production. Denmark became Norway's top customer for farmed salmon in 1991. Danish statistics show that imports of Norwegian salmon were 22,000 t worth about $134 million.[12] Competition for buyers was intense and "black market" sales of Norwegian salmon were reported as prices dropped precipitously. In addition, Danish importers pay more for Norwegian salmon than for any other salmon.[13] These factors make the situation for Faroese salmon producers extremely difficult, because they face higher production costs and almost half of their total exports go to Denmark.

The Faroe Islands reached an agreement with the European Community in 1991 which allows 4,900 t of fresh and frozen Faroese salmon (and 400 t of processed or canned salmon and trout) to enter the EC duty-free. The agreement gave Faroese exporters the room they needed to compete with Norway in the EC market. Unfortunately, the EC also imposed a minimum import price for Atlantic salmon in late 1991, following Scottish and Irish complaints of alleged Norwegian "dumping" salmon on the EC market. This minimum export price effects Faroese salmon exports as well as Norwegian, and once again makes their product more expensive than salmon produced within the EC. It did, however, result in a more level playing field in terms of competition from Norway. The FSFA regards this minimum import price as a trade barrier, because they fear that EC consumers will not purchase Faroese salmon at the higher price.

V. OUTLOOK

Faroese salmon farmers face a difficult year in 1992. Farmers are concentrating on cost effective operations, including automation and enlarging capacity. Farms which cannot mobilize the capital to undergo these changes will eventually be unable to compete. Faroese industry experts expect the number of companies operating in the Faroes to be drastically reduced before 1995. However, these analysts do not expect Faroese harvests to decrease. They base this belief on the economics of salmon farming: at current prices, a Faroese salmon farm must produce at least 300 t of salmon per year to be competitive and unit costs of production must remain below $4.80 per kilogram.[14] According to the FSFA, only 3-4 salmon farms currently produce between 800 and 1,000 t annually at unit costs below the target $4.80 per kg. If this is accurate, then the remaining 50-51 Faroese salmon farms produce somewhere between 235-272 t per year.[15]

There is, according to the FSFA, a natural incentive for the remaining salmon farms to expand production beyond the 300 ton mark or face bankruptcy. This should lead existing companies toward mergers and consolidations to increase efficiency and spread capital costs. Certainly the move to increase the production capacity of the remaining farms will make them more competitive, but the realities of survival in a competitive business climate could undermine this scenario. The Faroese Government is unlikely to offer significant financial assistance, and Faroese bankers are skeptical of salmon farming. In addition, the Faroese economy continues to suffer a recession.[16] The outlook for the Faroese salmon farming industry to obtain the finances needed to expand is uncertain. Thus, it is likely that Faroese harvests of salmon will see only a modest increase in the next few years.

SOURCES

"Faroe Farmers Move Offshore," *Fish Farming International*, April 1988, pp. 8-9.

Hansen, Søren, Senior Economic Specialist, U.S. Embassy, Copenhagen, Denmark. Facsimile transmission, August 4, 1992.

Hulgaard, Erling, Danish Ministry of Fisheries, Copenhagen, Denmark. Personal communication, August 4, 1992.

Roknskapur og fragreiding,1984, Foroya Banki.

"Salmon Farming in the Faroe Islands," The Faroe Oceanic Cultivating Organization.

"The Faroe Islands," *Facts about Denmark*, Royal Danish Ministry of Foreign Affairs, Copenhagen, Denmark, 1987.

***Figure 1.**—Map of the Faroe Islands.*

ENDNOTES

1. U.S. Embassy, Copenhagen, August 22, 1989.

2. Preliminary estimate obtained from industry sources. Final statistics are not yet available for 1991.

3. Søren Hansen, Senior Economic Specialist, U.S. Embassy, Copenhagen, Denmark, facsimile communication, August 4, 1992.

4. Prior to the storm there were 17 offshore cages (including 16 Bridgestone Hi-Seas cages and 1 Farmocean 3500 cage). No information is available on the number of cages damaged or destroyed by the storm.

5. Ken Chalmers, "Faroe Farmers Move Offshore," *Fish Farming International*, April 1988, pp. 8-9.

6. U.S. Embassy, Copenhagen, June 2, 1992.

7. Ken Chalmers, "Faroe Farmers Move Offshore," *Fish Farming International*, April 1988, pp. 20-21.

8. Søren Hansen, August 4, 1992. Embassy notes that they visited Faroese salmon farms, and observed location and conditions.

9. Ken Chalmers, "Faroe Farmers Move Offshore," *Fish Farming International*, April 1988, p. 20.

10. Estimate of value based on U.S. Embassy reports, and an estimate of average price obtained per kilogram of salmon during 1991.

11. Søren Hansen, August 4, 1992.

12. "Danes Profiting from Norwegian Salmon Exports," *Eurofish Report*, June 18, 1992, p. FS/1.

13. "Danes Profiting from Norwegian Salmon Exports," *Eurofish Report*, June 18, 1992, p. FS/1.

14. U.S. Embassy, Copenhagen, June 2, 1992.

15. Calculated by dividing the total number of farms (54 in 1992) by the remaining unallotted annual salmon production (between 12,000 and 13,600 t). Actual farm output is likely to vary greatly. No accurate statistics on the production capacity of Faroese salmon farms is available.

16. Erling Hulgaard, Danish Ministry of Fisheries, Copenhagen, Denmark. Personal communications, August 4, 1992.

Chapter IX
Western Europe

FINLAND

Finnish salmon culture is devoted almost exclusively to restocking Finnish waters. The direct benefactors of this policy are commercial and recreational fishermen in Finland. Catches of wild stocks of Atlantic salmon in Finland have declined from over 2.5 million before construction of hydroelectric dams blocked access to many salmon spawning grounds to fewer than 50,000 salmon in 1989. Finland began a massive restocking effort to rebuild their wild salmon populations during the 1980s. Finnish salmon culturists could not obtain enough eggs from their wild breeding stock to supply their restocking effort; therefore, they established a broodstock at state cultivation centers to supplement that supply. Restocking efforts appear to have met with some success, as catches of salmon have increased significantly during the restocking project. Finland's harvests of farmed salmon have stabilized at around 100 tons annually and are not expected to increase in the near future.

CONTENTS

I. GENERAL

A. Biology

Three species of salmon reside in Finnish waters. Baltic salmon (*Salmo salar L.*), Atlantic salmon from the Arctic Ocean, and a landlocked species of salmon (*S. salar m. sebago Girard*) which inhabits the Vuoksi Watercourse, are all native salmonids.[1] Apparently, all of Finland's major waterways once supported salmon stocks. Spawning populations originally inhabited 18 rivers running into the Baltic Sea, and 2 running into the Arctic Ocean.[2] Salmon fisheries have existed in the coastal areas of the Gulf of Bothnia for thousands of years and made permanent habitation by Finnish peoples possible along many of the rivers flowing into the Bothnian Bay.

B. Fisheries economy

Fishing and fish farming are important to Finland's economy. Finns consume around 25 kg. of fish and fish products per capita annually. Salmon fisheries in particular are of tremendous historical importance in Finland. Salmon is not only the most highly regarded fish in Finland, but the fish has played an important role in Finnish life dating back thousands of years. Indeed, salmon catches were historically so large that salmon catches in the Kemijoki River alone amounted to 350,000t annually during the early 1800s.[3] Salmon was the second most valuable species, after Baltic herring, for Finnish professional fishermen in the late 1980s. This explains why salmon culture for stock enhancement received such widespread and early attention in Finland.

Unfortunately, postwar reconstruction and the building and operating of hydroelectric dams took precedence over natural resources. This, together with dredging, flood control measures, logging operations, and water pollution adversely impacted Finland's stocks of wild salmon. Eventually, the Government recognized the environmental damage being caused and passed the Water Law of 1961 controlling activities that harmed the nation's waterways (see section D. below). The Government also began supporting efforts to restock the nation's salmon rivers. The results have been very positive in the last few years.

C. Aquaculture problems

Salmon diseases have not been as serious a problem in Finland as they have been for other countries. Furunculosis has surfaced in some Northern Finland salmon farms, but has been vigorously controlled. Finnish aquaculture is primarily concerned with maintaining the genetic purity of local strains of salmon. According to Finnish scientists, keeping broodstock for any length of time ultimately produces a new strain of salmon. Finnish salmon culturists have developed at least one artificial salmon strain, called the "Montta" stock after the farm on which it developed. Finnish culturists created this stock by mixing several strains which occur naturally in the Gulf of Bothnia. Aside from this experience, however, Finnish scientists have taken great pains to maintain distinct stocks that are as genetically pure as possible. To maintain genetic purity, Finnish culturists obtain their egg stock from the wild as much as possible.[4] However, because their wild populations are so severely depleted, Finnish culturists must rely on broodstock for most of their egg production. This careful attention to genetic purity has paid off in at least three instances: Finnish culturists are maintaining at least two strains in fish farms which have disappeared from the wild. Furthermore, scientists obtained Iijoki River salmon for culture during the 1960s; that stock has since disappeared, and is maintained in the river only by cultivation.[5]

D. Government policies

The basic regulation governing fish farming in Finland is the Water Law of 1961, which prohibits any activities which may alter the quality of Finnish waters. Licenses are issued by the Finnish Water Court. The National Board of Waters is responsible for enforcement. Fish farmers can obtain government grants and loan guarantees for beginning operations in isolated regions of Finland.

In view of the modest development of Finland's salmon farming industry it appears that the Government of Finland has not made salmon farming an important priority. Certainly, in contrast to the rainbow trout industry, the development of salmon farming appears meager. It is unlikely that the Finnish Government will provide much financial support to salmon farming in view of the decline in salmon prices in recent years. The long-term outlook is uncertain, but could change if world salmon prices increase in the next year or two.

II. HARVESTS

Finnish salmon culture concentrates on producing eggs and smolts for restocking Finland's wild salmon populations. Fish farming in Finland produces brood stock, spawn, and stocking fingerlings, but no farmed salmon destined for consumers. Although there have been experimental salmon farms, the last attempt to raise salmon on the Aland Islands failed and no further experimental farms are planned. Finland is, however, an important producer of rainbow trout for use as food. Finnish production of rainbow trout amounted to 17,000 metric tons (t) in 1991.[6]

A. Smolts

As early as 1771, Finnish fisheries specialists were recommending stocking salmon eggs into Finnish salmon rivers to boost populations.[7] Finnish biologists actually developed salmon hatcheries during the late 1800s. Salmon culture remained at the hatchery stage until the 1950s, when Finnish hatcheries began to cultivate 2-3 year old salmon smolts in the mouth of the Oulujoki River. Finnish salmon farmers stocked approximately 100,000smolts per year into Finnish rivers until the late 1970s. Since 1978, however, the number of smolt stocked in rivers has increased dramatically.

According to the Finnish Game and Fisheries Research Institute (FGFRI), salmon culturists stocked 672,000 salmon smolt age 1 year or older during 1980.[8]During 1981, Finnish fish farmers operated 338 smolt grow-out facilities, of which 253 were inland and 85 were marine water sites.[9] By 1982, culturists stocked more than 1.4 million juvenile salmon in Finnish rivers, and 2.1 million in 1984. By 1985, Finnish aquaculturists operated 461 smolt grow-out facilities. Two years later, culturists were able to release more than 3.6 million smolts. In all, the Finnish Government and the power companies which dammed Finnish rivers stocked more than 16 million salmon juveniles into Finnish rivers between 1980 and 1987.[10] In addition to restocking local rivers, Finnish scientists also began salmon restocking in the Gulf of Finland during 1976 and in the Bothnian Sea during 1979. During the expansion of the 1980s, about 20 percent of all Finnish salmon stocking was carried out in the Gulf of Finland, and about 15 percent in the Bothnian Sea.[11] Domestic smolt production now supplies all Finnish salmon culture needs. Indeed, when salmon farming in Norway and other European nations expanded rapidly during the 1980s, Finland exported some salmon smolts for foreign culture.[12]

B. Salmon

Finland raises few adult salmon; most are broodstock for stocking programs. Food fish production is minimal, and statistics are difficult to obtain.[13] The Finnish National Fisheries Board reported that experiments in farming Atlantic salmon as food fish in the Aland Islands were abandoned in 1991.[14] The harvest of farmed salmon in Finland has stabilized at an average of around 100 t per annum, and is not expected to increase in the future.[15] In part, this is attributed to efforts to raise large rainbow trout, which command a higher price in Finland. Also, however, the declining salinity of the Baltic Sea has made it less habitable for salmon, and prevents the development of large salmon populations.[16]

Finland's commercial catch of Atlantic salmon was 2,000 tons during 1991. The Board estimated that 90 percent of this catch was based on ranched stocks and 10 percent from wild stocks. Finnish fishermen were allowed to harvest wild salmon by the Baltic Sea Fishery Commission, provided that Finland continue to release 1.7 to 1.8 million smolts annually.

III. COMPANIES

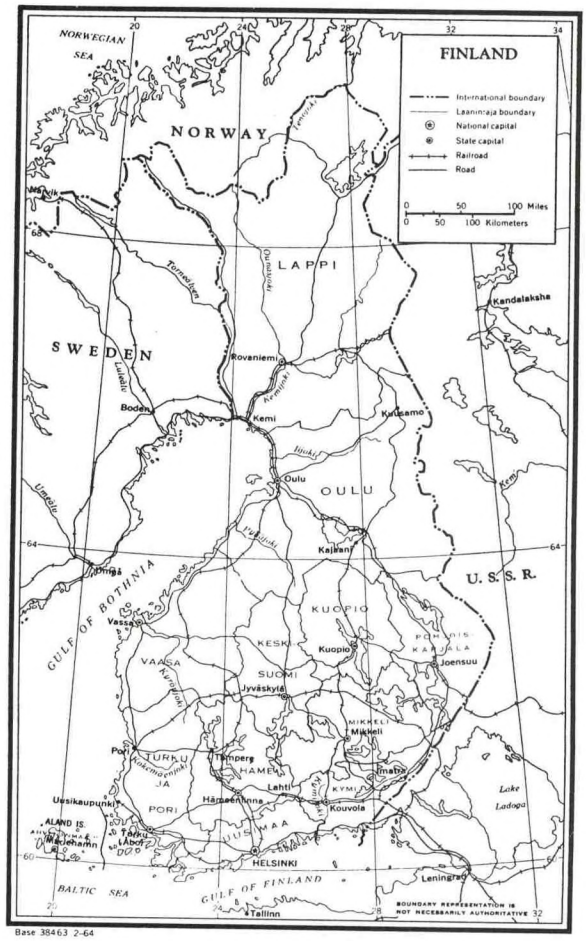
Finnish smolt culture is largely carried out by the state. Some private companies take part, often combining salmon smolt culture with their trout culture facilities. Hydroelectric plants in Finland also operate some hatchery and smolt facilities, as part of a program to reverse damage done to salmon stocks by extensive damming of Finland's rivers.[17]

IV. EXPORTS

Finnish salmon exports are not the product of grow-out farms. Rather, the few salmon that are exported represent smolts that have been released into the wild and caught as *wild* fish. Exports of salmon (wild or farmed) from Finland are negligible.

V. OUTLOOK

Finland's salmon stocking project has been quite successful. Finnish fishermen report catching increasing numbers of Finnish-stocked salmon since the program began in 1981.[18] In fact, estimates of return from the 1987 year class demonstrated that each 1,000 smolt released yielded 400-600 kg of wild salmon caught in Finland's waters.[19] Because these yields are so good -- especially given the mixed results of world stocking programs for various species -- there is every reason to believe that Finland will continue its salmon restocking efforts. Indeed, before the world farmed salmon price collapse during 1989, experts predicted that Finland would increase its salmon production to include farm-raised salmon for food fish.[20] Given the spending squeeze which most Scandinavian governments are currently feeling, however, it seems unlikely that the Government of Finland will encourage the development of a salmon grow-out system at this time. Should world salmon prices increase, it is possible that Finland could become a modest producer of farm-raised salmon in the future.



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Lindqvist, Ossi V. "Fish Farming in Finland," Canadian Translation of Fisheries and Aquatic Sciences No. 5273, Canada Institute for Scientific and Technical Information, National Research Council, Ottawa, Ontario, 1986, p. 23.

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Westman, Kai. "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 22.

ENDNOTES

SECTION I (General)

1. Scientists disagree as to the proper application of the term "salmon" to several species of salmonids. Many do not recognize landlocked species as true salmon: as such, some would argue that Finland has only one or two true species of "salmon."

2. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 22.

3. Ossi V. Lindqvist, "Fish Farming in Finland," Canadian Translation of Fisheries and Aquatic Sciences No. 5273, Canada Institute for Scientific and Technical Information, National Research Council, Ottawa, Ontario, 1986, p. 23.

4. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 27.

5. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 23.

SECTION II (Harvests)

6. U.S. Embassy, Helsinki, July 8, 1992.

7. Westman cites the doctoral thesis of C.R. Gjers published in 1771, which recommended stocking the Kokemäenjoki River with additional salmon eggs. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 24.

8. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 25.

9. Ossi V. Lindqvist, "Fish Farming in Finland," Canadian Translation of Fisheries and Aquatic Sciences No. 5273, Canada Institute for Scientific and Technical Information, National Research Council, Ottawa, Ontario, 1986, p. 1.

10. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 25.

11. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 26.

12. U.S. Embassy, Helsinki, August 21, 1989.

13. It is very difficult to obtain specific information on farmed salmon production in Finland. This is partially due to the largely restocking goal of Finnish salmon culture, which makes it difficult to obtain export statistics. It is greatly complicated by the extensive culture of rainbow trout (*salmo trutta*), which is often reported together with Atlantic salmon production.

14. U.S. Embassy, Helsinki, July 8, 1991.

15. Ralph Goff, U.S. Embassy Science Officer, Helsinki, in a fax dated August 3, 1992.

16. Mr. Kari Airaksinen, Senior Inspector at the Fisheries Economics Office of the Ministry of Agriculture in Finland. Reported by Ralph Goff, U.S. Embassy Science Officer, Helsinki, in a fax dated August 3, 1992.

SECTION III (Companies)

17. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 27.

SECTION V (Outlook)

18. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p. 29.

19. Westman quotes a Finland governmental study of data on returned salmon tags, which are used to mark stocked smolts. The study states that each 1,000 smolt stocked yield 300-400 kg of fish captured. Because many tags are never returned to the government by Finnish fishermen, however, the study estimated that the actual yield was closer to 600 kg per 1,000 smolt stocked. Kai Westman, "Salmon Rearing and Stocking in Finland," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-operation and Development, 1989, p.29.

20. U.S. Embassy, Helsinki, August 21, 1989.

Chapter IX
Western Europe

FRANCE

The French market for salmon is very lucrative. During the 1980s, demand for fresh and frozen salmon in France increased dramatically, and imports levels rose more than 200 percent. Farmed salmon, however, represents only a small portion of total French aquaculture production, despite the efforts of both public research institutions and private companies. There have been several experimental salmon farms in France, but, over the years, farmers have had difficulty maintaining good survival rates and producing farmed salmon large enough to compete with imported farmed and wild salmon on the French market. This is because the sea temperatures rapidly increase during the late spring and summer months. A new salmon aquaculture project was undertaken in August of 1988 by Salmor, a company formed by French and Norwegian interests, which appears to have changed the outlook for the salmon aquaculture industry in France. By raising farmed salmon in the tanks of barges on the open sea, Salmor helped to increase the French salmon harvest from 60 metric tons in 1989 to approximately 1,200 tons in 1990 when its first harvest was completed.

CONTENTS

I. GENERAL

A. Overview

Salmon farming in France is concentrated in the northwest region of Brittany (Camaret and Le Conquet). The predominant species harvested is Atlantic salmon (*Salmo salar*), although there has been some production of Pacific coho salmon (*Oncorhynchus kisutch*) through pilot programs sponsored by government agencies.

B. Historical development

Salmon farming in France began in the early 1970s as part of a research collaboration between the Centre national pour l'exploitation des océans (CNEXO) and the National Marine Fisheries Service (NMFS) of the U.S. Department of Commerce. The project established commercial coho salmon aquaculture in the Brittany region of France. Beginning in 1974, annual shipments of coho eggs from U.S. hatcheries in the Pacific Northwest were made to a salmon farm located on the lagoon of Carpont in north Brittany. The Carpont station was comprised of 16 floating net cages, 10 meters in diameter and 3.5 meters deep.[1] The climatic conditions in Brittany were quite favorable for the smolting stage. However, the first two years of operation showed heavy mortality rates in the late spring and summer because of the temperature differences encountered when transferring the smolts from colder fresh water to warm sea water. The salmon that survived often did not grow large enough to compete with imported farmed and wild salmon on the French market. Therefore, a technique was developed whereby, when conditions permitted, smolts were placed in the sea rearing facilities in the autumn after the sea temperature had dropped; the result being that the salmon were grown for market from October to May. The project yielded 7.6 metric tons (t) in 1974 and 25 t in 1975.[2]

Farmed salmon harvests remained very consistent, though rather low, for over a decade, averaging 40-80 t annually. By the mid-1980s, the development of coho production remained limited. In addition to the species sensitivity to the climatic conditions in Brittany, France was still dependent on imports of eggs from the United States and Canada. Furthermore, at this time, Norway and other countries were experiencing growing success with

Figure 1.--Map of France.

their production of farmed Atlantic salmon, and experiments were revealing that Atlantic salmon was more resistant to the rapidly increasing summer temperatures in Brittany than coho salmon.[3] Since 1987, companies have shifted their emphasis from farming coho to farming Atlantic salmon.

Pilot programs for the production of Atlantic salmon were also established on the islands of St. Pierre and Miquelon, off Canada's Atlantic coast, in the mid-1980s. In addition, the French National Institute for Agronomy Research (INRA) began a sea-ranching operation on the Kerguelen Islands in the southern Indian Ocean in 1983.[4]

II. HARVESTS

French harvests of farmed salmon averaged between 40 t and 80 t annually throughout the 1970s and most of the 1980s,. During this period, however, emphasis shifted from coho production to farming Atlantic salmon. There was a dramatic increase in salmon production from 1989 to 1990 because of a new Atlantic salmon aquaculture project sponsored by a company called Salmor. The 1990 harvest totaled approximately 1,200 t, valued at US$8 million, whereas total French production in 1989 amounted to

only 85 t of Pacific salmon. Trade sources report that France is going to stop the production of coho salmon and focus entirely on Atlantic salmon. Harvests are estimated at 1,400 t for 1991 and are expected to reach 1,800 t in 1992 and 2,000 t in 1993.[5]

III. COMPANIES

The first non-experimental Atlantic salmon farm was set up in May 1987 by **Norsklaks**, a Norwegian firm under the direction of Svein Moldskred. Six floating cages were constructed at the end of the major causeway in the oil port of Antifer, located in the Le Havre region of Normandy on the Baie de la Seine. Smolts for the project were imported from Norway; approximately 50,000 smolts arrived by cargo in the first week. Although it was feared that many of the fish might die due to stress from the voyage, the majority survived and were quite healthy. In the first three months, there was only a 2 percent mortality rate.[6] The farm's harvest for 1988 was expected to reach 120 t. However, only 60 t of Atlantic salmon was actually harvested that year, because a violent storm carried away a significant number of the fish. Production for 1990 was projected at 180 t.[7] More recent information on Norsklaks is not available at this time.

Salmor was organized in August 1988 as a joint project between the Norwegian firm Scanfarm and a group of local investors from the northern region of Brittany. Scanfarm owns approximately 33 percent of the company, and the local investors own the other 67 percent, of which three Breton companies, Even, Quemener, and Keryvon, make up the majority.[8] Salmor approached salmon farming somewhat differently than its French predecessors; it decided to convert an ex-Portuguese oil tanker into a floating salmon farm.[9] The ship, *L'Ile Sous Le Vent*, is 116 meters long, equipped with four 4,000 cubic meter holds, and has a capacity of 500,000 smolts that can yield about 750 t of grown salmon. Salmor chose to anchor the ship 5 kilometers off the coast of Brittany in the Baie de Morlaix. It became operational in mid-1989 when 230,000 smolts were delivered from Norway.[10] The ship brought in its first harvest of approximately 600 t in the spring of 1990; the salmon weighed and average of 2.5 kg.[11] The following November, Salmor lost almost all of its second batch of smolts from Norway because of a failure in the water circulation system that suffocated the fish. At that point, the company made some technical improvements to the ship and decided to extend the growing time and market the salmon at a weight of 5 to 7 kg. In April 1991, 250,000 smolts were delivered from Norway and Ireland. Salmor hopes to double its smolt intake in 1992.[12] Additionally, another ship was supposed to become operational in 1991.

The current manager of Salmor is Philippe Magaldi. The address of the company is:

Salmor
Port De Blascon
29689 Roscoff
France

IV. THE FRENCH MARKET

France is the largest European market for salmon and the world's largest salmon importer. The market for salmon in France is very lucrative, as it is worth nearly US$400 million. French demand for salmon, especially Atlantic salmon, increased considerably during the 1980s; import levels rose 200 percent. Traditional suppliers to the French market included the United States and Canada. They controlled 93 percent of the market in 1986, supplying mainly wild Pacific salmon that was frozen months before delivery to French consumers. The North American share of the valuable French market, however, plummeted to only 38 percent in 1990. The French began to develop a strong preference for fresh Atlantic salmon as it became more available and price competitive during the late 1980s. Atlantic salmon farmed in European countries such as Norway and the United Kingdom could reach the quality conscious French consumers within hours of harvest, whereas wild salmon imported from North America took months to reach France after harvest. Norway's market share increased from 4 percent to 47 percent between 1986 and 1990.[13]

France imported 68,255 t of salmon valued at US$380 million in 1990 and 77,945 t worth over US$386 million in 1991. Norway's share of the French market increased to over 60 percent in 1991; the United Kingdom held 21 percent, Ireland 10 percent, and the Faroe Islands just over 5 percent. The U.S. and Canada combined had a market share of less than 1 percent for 1991.

V. OUTLOOK

The French salmon aquaculture industry has an advantage over many other salmon producing countries: there is already a strong domestic market for their product. If farmers can successfully grow high quality salmon capable of competing against imported products, harvests are likely to increase to some degree. It is unlikely that production will shift back to coho salmon since French demand for Atlantic salmon has grown so much. Although some progress in salmon farming has been made by Salmor, there is no indication that France will become a major producer of salmon in the near future.

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ENDNOTES

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2. "French Salmon Project," *Fishing Industry Board Bulletin*, March 1977, p. 2.

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4. *Aquaculture and Capture Fisheries: Impacts in U.S. Seafood Markets* (Washington, DC: U.S. Department of Commerce, 1988), p. 96.

5. Production figures for 1982-83 and for 1989-93 were provided by the U.S. Embassy in Paris.

6. Richard Goasguen, "Les saumons d'Antifer: croissance satisfaisante," *Le Marin*, December 11, 1987.

7. "200 kg de saumon français vendus en criée," *La Pêche Maritime*, February 1990, pp. 82-83.

8. Alain Le Duff, "Élevage de saumons en baie de Morlaix: Salmor et ostréiculteurs même combat!" *Le Marin*, August 12, 1988.

9. The ship is also called a barge in various trade journals. The salmon are grown in tanks that once held oil.

10. "A Review of World Salmon Aquaculture," *Marine Fisheries Review*, 1991, p. 35.

11. Alain Le Duff, "Salmor: Pari technologique gagné," *Le Marin*, May 18, 1990, p. 26.

12. "Larger Fish from Barge," *Fish Farming International*, April 1991.

13. Marie Christine Monfort and Jorun Andreassen, "France," *Salmon Market Newsletter*, December 1990, pp. 6-7.

Chapter IX
Western Europe

ICELAND

Iceland ranks among the world's top 15 fishing nations, harvesting between 1 and 2 million metric tons of fish and shellfish annually. The country has a long history of raising salmon smolts for release into the wild as part of a program to enhance wild salmon stocks. In 1984-85, Norwegian investors discovered Iceland's natural resources and began to invest heavily in raising salmon smolts for export, release into the sea (ranching), and for use in very large salmon grow-out farms. Salmon aquaculture enjoyed a brief period of growth which generated great publicity and helped expand the industry. In 1989, however, Norwegian salmon harvests expanded rapidly, exceeding the ability of Norwegian exporters to market their product profitably. World market prices dropped significantly, disrupting fish farmers around the world. Many Icelandic salmon farmers faced bankruptcy. The situation in the past few years has been poor and Icelandic farmers have been unable to recover. Salmon farming allows Iceland to supplement the nation's income from harvests of wild fish stocks. Exports of fishery products generated $1.4 billion in 1990, or nearly 75 percent of the nation's foreign exchange revenues. Markets for Icelandic salmon were beginning to contribute significant returns to the economy before world prices dropped. Iceland has the potential to export fresh salmon to the United States -- a market dominated by Norway before the U.S. Government placed anti-dumping and countervailing duties on imports of Norwegian products -- but low U.S. prices, an adverse exchange rate, and improving European prices have prompted Icelandic exporters to turn to Europe. Icelandic salmon harvests are expected to increase slightly in 1992.

CONTENTS

Figure 1.--Map of Iceland.

I. GENERAL

A. Overview

Iceland has a long history of releasing farmed smolts into the wild as part of a restocking program aimed mostly at enhancing sportsfishing. There are about 80 rivers in Iceland where salmon are caught by anglers and in nets. Net fishing is permitted only in murky, glacier rivers. This is the only area where even a limited form of commercial fishing is permitted. All rivers and lakes in Iceland belong to the region's land owners, who are required to organize fishing clubs to control exploitation of fishery resources.[1] Rivers have been made accessible to spawning fish by the construction of ladders. Commercial fishing for salmon at sea has been prohibited since 1932.[2]

The first fish farm established in Iceland was a pilot station at Laxalón near Reykjavik started in 1951[3]. The farm began by experimenting with rainbow trout. The owners of the station established a new farm to raise salmon in 1953 at Ellindaár, on the outskirts of Reykjavik[4]. The Icelandic government began experimenting with salmon "ranching" when it established the State Experimental Fish Farm at Kjollafjördur in 1961.[5] The program gradually expanded, and by the early 1980s the Government operated approximately 40 hatcheries and research stations which were involved in restocking or ranching programs. The Icelandic ranching program was based on the natural urge of salmon to return as mature adults to their natal rivers (where they could then be harvested). This approach was taken because (1) Iceland lacked the many protected fjords commonly found in Norway, (2) water temperatures are extremely cold during the severe Arctic winters, and (3) because the technology did not exist for offshore pen systems able to withstand Iceland's severe weather conditions. The first experiments in rearing salmon for human consumption were started in 1973; these attempts failed.[6] New experiments in pen culture, however, were resumed. Salmon ranching and farming yielded a combined harvest of 20 metric tons (t) in 1981.

B. Special features

Iceland has many natural resources that make it suitable for growing salmon, as well as formidable features that inhibit production. When salmon farming was first considered, the problems of raising salmon appeared quite daunting. Later, with more experience and the advances made by the producers of offshore pens able to withstand severe winter weather, the industry was able to focus on the nation's special features.

Some of the inhibiting factors include very **harsh winter weather**. Tremendous storms and freezing Arctic weather make any operation dangerous. Maintaining scheduled feeding and servicing of floating pens in gale conditions is nearly impossible. Iceland does not have a series of deep fjords, protective islands, or sheltered bays forming natural barriers to the high winds and huge waves that sweep the coast. Until the maritime industry was able to manufacture offshore pens able to withstand the winter storms that routinely sweep across the North Atlantic, there was little that Icelandic fish farmers could do. **Very cold waters** inhibit salmon from feeding and the long winter season produces only a very short season for growth. As a result, development was slow in the beginning. **Shallow fjords** and **tremendous differences between high and low tides** (nearly 4 meters in some places) made pen rearing operations difficult in those few fjords or bays that were sheltered. The development of offshore platforms able to withstand severe weather allowed the industry to expand. The expansion went in two directions: offshore and inshore. Those that remained inshore either built expensive land-based facilities or located in some of the few areas where natural barriers protected the facilities from the relentless pounding of the North Atlantic.

Later, some of Iceland's natural advantages were employed. Iceland has **enormous natural sources of hot water from geothermal springs**. Iceland's geothermal springs provide salmon farmers with a natural source of pure, warm water that is ideal for raising smolts. This water allows smolts to grow rapidly and made Icelandic smolts very popular in Norway and Ireland. It also helps Icelandic salmon ranchers to grow hearty stocks for release into the challenging North Atlantic environment. Iceland is also fortunate to have **unpolluted waters** with strong currents that keep pens clear of accumulated wastes. Strong currents force the fish to swim constantly and produce a lean, healthy fish. Iceland also has a skilled fishing industry with access to **stocks of capelin**, an important ingredient of salmon feed. Unfortunately, capelin stocks are subject to dramatic fluctuations. Finally, the nation has a core of **well-educated technicians, engineers, research scientists, bankers, and government officials**. This human talent was an important factor that helped the industry evolve in a careful, well-developed manner.

C. Role of government

1. Financial support

During the initial stages of development the Government of Iceland (GOI) played little or no role, except in the approval of sites and control of health regulations. The GOI made a point of saying that it provided no subsidies to the industry. This policy appears to have changed by 1985, when the GOI announced $12 million (500 million Icelandic krona) in low-interest loans were being made available to individuals seeking to start or expand fish farming operations.[7] In 1988, Iceland's Prime Minister, Steingrímur Hermannsson, promised a government initiative to solve the short-term financial problems faced by Iceland's fish farmers.[8] It was reported that 32 farms in Iceland had inventory loans covering 37.5 percent of the insured value of their stocks. A few additional farms had loans exceeding 50 percent of the insured value. Fridrik Sigurdsson, Managing Director of the Federation of Icelandic Fish Farms, claimed that Icelandic fish farms needed credit equivalent to 65 to 75 percent of their insured value of stocks to operate.[9]

2. Administrative control

Responsibility for regulating the development of fish farming in Iceland is shared by a number of different agencies. The Health Protection Agency (a consultative body under the Ministry of Health) has the authority to issue operating licenses. The Nature Conservation Council (an advisory body) has the right to veto projects considered detrimental to the environment. The Directorate of Freshwater Fisheries is a government agency established to promote the growth of the salmon farming industry. The Pathology Division of the Directorate of Veterinary Services (DVS), of the Ministry of Agriculture, has primary responsibility for controlling fish diseases. Samples are taken from smolt farms on a routine basis and if any trace of disease is found, the farm is denied the right to export. Strict measures are taken to make sure that diseased fish do not contaminate surrounding farms. Buyers of smolts invariably demand that the veterinary services approve the smolts they intend to buy. Thanks to these efforts, Icelandic salmon farms have been remarkably free of disease.

II. HARVESTS

A. Hatcheries

The Government of Iceland operates approximately 40 hatcheries and research stations involved in restocking or ranching programs. These facilities did not provide smolts to Icelandic salmon farms, and most commercial operations reportedly imported smolts from Norway to begin their operations. Most farms have since established their own broodstock and are able to meet their own requirements for eggs.

B. Smolts

Icelandic research stations had a fairly good knowledge of raising smolts for release into the wild, and the Icelanders put this knowledge to quick use. There were 16 smolt producers operating in 1985 with a production of 821,700 smolts, an increase of 4 percent over 1984 production. Icelandic smolt producers began exporting large quantities of smolts to Ireland and Norway in 1985, when smolt prices increased by 80 to 100 percent. Icelandic exports to Norway partially were the result of Norwegian imports of smolts infected with furunculosis (caused by *Aeromonas salmonocida*) from Scotland in 1985. Icelandic smolts are considered to be of an unusually high quality and more than 700,000 Icelandic smolts were shipped to Norway in 1985 and an additional 80,000 smolts were shipped to Irish salmon farmers. An important joint venture smolt operation was initiated in 1985.

The number of firms growing smolts in Iceland increased in 1986 to 36 farms with a capacity of 5.3 million smolts. Icelandic exporters shipped more than 1 million smolts worth $2 million to Ireland and Norway in 1986. The high demand for smolts in export markets resulted in some shortages of smolts inside Iceland. Lindarlax, one of the largest fish farm in Iceland, was created by Norwegian and Icelandic investors in 1986, with plans to produce 5 million smolts and 6,000 tons of mature salmon; this was 6 and 40 times greater than the entire Icelandic production for 1985.[10] Over-enthusiastic projections such as this were part of the "boom" mentality sweeping the country during the mid-1980s. In 1987, however, Norway was able to significantly expand its own smolt production, and demand for Icelandic smolts dropped. Other nations also succeeded in producing sufficient smolts to meet their domestic requirements

and the lucrative export market for Icelandic smolts began to decrease. This made more smolts available for ranching or farming, and a decision was made to promote grow-out of salmon as a means of countering the loss of export markets for smolts.[11] Smolt production was 7.2 million in 1991, nearly half the 15 million capacity of the industry. Iceland's smolt production included 1.3 million "super" smolts in 1991. There were 60 smolt growing sites operating in Iceland in 1991.[12]

C. Salmon

1. Ranching

One of the first ocean-ranching companies established in Iceland was operated by pioneer breeder Jón Sveinsson at his farm at Lárós on the Snaefellsnes peninsula. Mr. Sveinsson was reporting returns of large salmon of around 10 percent by 1983.[13] Silfurlax hf., founded in 1985, operates a facility in Hraunsfjördur in southwestern Iceland. The firm buys its smolt from a production station in Núpar. After raising the smolts for several months, they are released into the North Atlantic to feed and grow. Silfurlax reportedly releases about 3 million smolts annually. After one or two years, they instinctively return to Hraunsfjördur where they are harvested. They generally weigh from 1.5 to 9 kg upon their return. Óskar Hallgrímsson, Marketing Director for Silfurlax, claims that harsh North Atlantic conditions produces a top-quality, lean fish with a uniform distribution of body fats. The firm reported marketing 400 t of ranched salmon during 1991 (mostly to Europe) and expected to increase production to 800 t in 1992.[14]

An important step in the salmon farming/ranching industry took place in 1986, when the Freezing Plants Corporation of Iceland, the nation's biggest seafood processor, announced that it had paid $530,000 to purchase shares in a sea ranching operation and smolt producing farm 15 km from Reykjavik.[15] This was the first major investment by a well-established Icelandic seafood company in the salmon business. It also marked the start of an era of rapid expansion in salmon farming that would characterize the industry for the next 2 years. According to Icelandic scientists, salmon ranching operates on fairly small margins. During 1989 and 1990, return rates for ocean-ranched salmon were only 1-3 percent for both one- and two-year old salmon. Typically returns for one-year old salmon average around 7 percent. Cold spring weather reportedly contributed to poor return rates and to lower body weights of those fish that did return.[16] There were 14 licensed salmon ranching sites in Iceland during 1991/92.[17]

2. Grow-out farms

The first salmon grow-out farm producing farmed Atlantic salmon for sale to consumers apparently began operating in 1980. The firm was called Iceland-Norway (ISNO) and involved Mowi of Norway as one of the partners (reportedly with 55% ownership) in cooperation with Eyjólfur Konrád Jónsson as the Icelandic partner. The company reportedly was based at Lón in Kelduhverfi (at Axarfjördur) in northern Iceland. The company reportedly released 15,000 smolts into their pens in July 1980.[18] The farm harvested 4.5 t of salmon in the beginning of December 1981,[19] and made a second harvest in February 1982.[20] It appears that the initial venture proved very profitable. As a result, ISNO apparently decided to invest in additional salmon farming operations. A new ISNO salmon joint-venture farm began operations at Oxarfjordur where it produced 35 t of farmed salmon in 1984 and 85 t in 1985. This new operation has partners identified as Mowi of Norway (45% ownership) and Tungulax of Iceland (55% ownership). The Fisheries Association of Iceland opened an experimental research station at the ISNO site in 1987. The ISNO operated a series of floating pens in a lagoon protected from severe weather by a sand bar with two openings to the sea. A unique feature of the ISNO farms was that they were among the first to utilize water from Iceland's abundant geothermal springs, offsetting the affects of the cold winter weather and water of the region. Heated freshwater was used to maintain a constant water temperature. The facility was able to produce salmon weighing 1.5 kg to 5 kg in two years. The ISNO raised its own smolts and released a small quantity of smolts into the sea as part of a salmon ranching operation.

One of the world's largest land-based salmon farms was opened at Stad near Grindavik in 1984. The farm, Strandeldisstod Islandslax Ltd., was a joint venture operation between Iceland's Samband (51 percent ownership) and Norlax of Norway (Noraqua and Teleinvest, with 49 percent ownership). The operation received funding from the Nordic Investment Bank and began operating in 1984, with the installation of smolt tanks. The company initially imported salmon eggs from Norway, but quickly became self-sufficient in egg production. The operators based their production plans on an estimated export of 300 t of salmon to the United States and 300 t to the United Kingdom. They planned to produce a total of 700 t by 1990. Islandslax Ltd. also planned to export "super smolt" weighing about 150 grams (as opposed to 50 gram smolts). Super

smolts grow very rapidly in Iceland because of the abundance of geothermal springs that provide clean, hot water to the grow-out pens. Islandslax harvested 1 million smolts in 1986. Most were reportedly exported to Ireland. A small quantity were used by the company for its salmon grow-out program. Operations were so successful that the company built a new farm hope would eventually be able to produce 5,000 tons annually. However, the firms has only produced 650 t per year.[21] Islandslax allowed the Icelandic Marine Research Institute (MRI) to establish a research station at their farm to observe their experimental programs, which included the breeding of Atlantic halibut. In 1990, the chief executive of Iceland Salmon Ltd. (Islandslax) planned to produce 250 tons of gutted fish. He also indicated that a new subsidiary, a land-based farm operated by Laxalind (formerly Lindalax, which went bankrupt), would produce another 1,000 tons.[22] This projection was also optimistic; actual production has averaged 200 to 300 t per annum.[23] Norwegian investors also created a joint venture salmon farm, Lindalax Ltd., representing Seafood Development A/S of Norway (49%) and Lindalax of Iceland. The farm is situated in Vatnsleysuströnd, southwest of the Reykjavik. The farm, which began operations in 1988, expected to produce 1,100 tons starting in the autumn of 1989. The cost of the building was estimated at $5 million.[24]

Thanks to the leadership and financial contributions of Norwegian investors, the number of salmon farms in Iceland increased from 18 farms in 1985 to 50 farms in 1986. The National Research Council of Iceland optimistically reported that production of fish farms could reach 25,000 t by the end of the century and might account for as much as one-quarter of Iceland's total export earnings.[25] The big surge in production came in 1987 when production increased to 800 t and then to 1,750 t in 1988. Salmon harvests nearly doubled to 2,500 t in 1989 and again to 5,000 t in 1990. During this period the salmon farming industry divided into two sectors: those operating shore-based farms and those operating deep-sea pens. The advent of modern technology allowed Icelandic salmon farmers to increase production.

In 1989, however, Norwegian salmon farmers began harvesting enormous quantities of salmon. Harvests were so great that they could not be marketed in an orderly manner and prices began to decline. This situation continued through early 1992, and affected salmon farmers all over the world, including Icelandic salmon growers. The Icelandic Government reported that the domestic salmon farming industry was expected to suffer losses of over $135 million in 1991. Many salmon faced bankruptcy as world prices declined so severely that many Icelandic companies could not compete. Iceland's total harvest was 3,030 t worth $33 million in 1991.[26] Production came from 17 land-based, 13 sea-cage sites, and 7 research facilities in 1991.[27]

The Icelandic Fish Farmers and Sea Ranchers Association was formed to promote the interest of salmon farmers and ranchers. The association established a code of "Good Aquacultural Practice" to improve the quality of Icelandic salmon. One unique feature of Iceland's land-based farms is that they use flowing water to keep the fish constantly swimming; this produces firmer flesh and a lower fat content.[28] The Association also developed its own seal of quality to help identify Icelandic product in overseas markets.[29]

Figure 2.--Quality symbol for Icelandic farmed salmon.

III. EXPORTS

A. United States

Iceland first shipped small quantities of smoked salmon to the United States in 1982 and began shipping fresh salmon in 1983. Exports increased sharply in 1988 when over 300 t worth $2.5 million were imported by U.S. seafood dealers. The U.S. market purchased over 1,000 t worth nearly $5.9 million in

1990, but then decreased to just under 800 t wroth $4.5 million in 1991 (see U.S. import statistics in the Appendix section). U.S. import statistics for 1992, reflect a continued decline in shipments of Icelandic farmed salmon: fresh salmon imports from Iceland were 204 t worth $1 million through May 1992. Frozen salmon imports were 2 tons worth only $17,000 and imprts of smoked Icelandic salmon were 32 t worth $394,000. Vilhjálmur Guõmundsson, of the Export Council of Iceland noted that low prices for salmon in the United States, an unfavorable exchange rate, and better prices in Europe have contributed to decreased sales of Icelandic salmon to the United States in recent months. The United States, was, however, Iceland's second largest customer (after France) for farmed salmon, accounting for nearly 36 percent of the country's total salmon exports.[30]

B. Europe

The EC accounted for almost 71 percent of Iceland's total fishery exports (versus just under 60 percent in 1989). Iceland has been successful in selling its salmon in Europe, particularly in France. According to Lúdvík Jónsson, of Icelandic Freezing Plants Corporation (IFPC), the French were willing to pay higher prices for Icelandic salmon. Jónsson claimed that Icelandic salmon reached the French market before Norwegian salmon and was thus fresher. Also, the smaller sizes of Icelandic salmon were popular in France. IFPC sold 224 t of salmon in Europe in 1989, 100 t of which was sold in France.[31] France was Iceland's most important client in 1991 (42 percent of all salmon exports), followed by Denmark (11 percent), Switzerland (3 percent), Belgium (1 percent) and other countries.

C. Other

Icelandic sales to Japan began with the shipment of fresh product to Tokyo via Flying Tigers airline and later by Icelandair. The prices received in Japan, according to Fridrik Sigurdsson of Iceland Salmon, are "the best."[32] Unfortunately, Flying Tigers stopped their service to the Orient through Iceland and exports have since declined. Exports of all "other" countries accounted for only 8 percent of Iceland's total 1991 salmon exports.

IV. OUTLOOK

The outlook for Icelandic salmon farmers and ranchers remains clouded. Icelandic salmon products enjoy a good reputation on world markets, from smolts to harvested salmon. It is difficult to measure the full extent of the economic dislocation suffered by Icelandic farmers and ranchers in the last few years. Opportunities to expand are good and the outlook for higher prices starting in late 1992 appears to be good. It is too early to say how Icelandic salmon exporters will react to these positive signs and if the industry has the ability to recover rapidly in the near future.

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Appendix B

Iceland

Table 1.--Iceland. Smolt production and harvests of farm-raised and ranched Atlantic salmon, 1980-91.

Year	Smolt production	Salmon harvests		
		Farmed	Ranched	Total
	Millions	Metric Tons		
1980		5		5
1981		20		20
1982		30		30
1983		50		50
1984		107		107
1985		91	58	149
1986		58	65	123
1987		490	40	530
1988		1,053	180	1,233
1989		3,782	118	3,900
1990				3,500
1991	7.2			3,030

Source: "Icelandic Forecast High in 1990," *Fish Farmer*, July/August 1990, p.25 (data for 1985-1989). "Good Start for Fish Farm," *News from Iceland*, January 1982 (data for 1980). Vihjálmur Guömundsson, Export Council of Iceland, for 1990-91 production.

Table 2.-- United States. Imports of salmon from Iceland, 1982-91.

Year	Imports			Total	
	Fresh	Frozen	Smoked	Quantity	Value
	Metric Tons				*US$1,000*
1982	0	0	.2	0	3
1983	.4	0	0	0	2
1984	5	0	.1	5	32
1985	5	0	.1	5	35
1986	54	1	.1	55	436
1987	79	0	0	79	683
1988	325	1	0	326	2,554
1989	478	98	9	585	3,061
1990	1,016	68	9	1,093	5,879
1991	750	9	38	797	4,451

Source: U.S. Bureau of the Census.

Table 3. --United States. Imports of fresh salmon from Iceland, by quantity and month, 1983-91.

Month	Fresh Imports								
	1983	1984	1855	1986	1987	1988	1989	1990	1991
	Kilograms								
January	0	0	1,361	0	0	16,026	11,875	36,021	18,662
February	0	1,361	0	0	0	11,092	20,936	47,239	14,482
March	0	0	0	0	0	26,864	26,021	74,911	27,582
April	0	0	0	0	0	38,373	38,076	94,849	88,887
May	0	0	268	7,128	14,034	55,404	72,706	130,575	126,181
June	0	0	0	26,572	29,157	34,471	54,180	159,332	158,933
July	0	0	0	15,415	4,313	18,003	44,881	148,811	90,988
August	0	0	2,435	1,908	9,893	5,349	28,964	102,142	50,490
September	430	1,025	0	0	1,932	10,809	55,193	59,681	62,402
October	0	0	0	2,696	2,527	26,788	25,303	77,968	54,921
November	0	0	0	0	5,349	43,677	41,300	40,757	38,650
December	0	3,016	871	0	11,822	38,563	58,085	43,861	18,214
TOTAL	430	5,402	4,935	53,719	79,027	325,419	477,520	1,016,147	750,392

Source: U.S. Bureau of Census.

Table 4. --United States. Imports of frozen salmon from Iceland, by quantity and month, 1986-91.

Month	Frozen Imports					
	1986	1987	1988	1989	1990	1991
	Kilograms					
January	0	0	0	2,744	0	0
February	0	0	0	5,095	3,048	0
March	0	0	0	9,358	1,149	0
April	0	0	0	23,622	2,501	0
May	0	0	0	8,401	8,174	0
June	0	0	0	0	10,583	0
July	1,270	0	0	7,782	11,293	0
August	0	0	0	12,243	10,657	7,658
September	0	0	0	12,264	8,598	1,806
October	0	0	600	6,458	11,777	0
November	0	0	0	5,489	0	0
December	0	0	0	4,262	0	0
TOTAL	1,270	0	600	97,718	67,780	9,464

Source: U.S. Census Bureau.

Table 5. --United States. Imports of smoked salmon from Iceland, by quantity and month, 1982-91.

Month	Smoked Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	0	0	0	0	64	0	0	0	224	1,362
February	0	0	0	0	0	0	0	0	234	316
March	0	0	0	0	0	0	0	239	446	321
April	0	0	0	0	0	0	0	157	631	1,473
May	0	0	0	0	0	0	0	444	2,336	1,053
June	0	0	0	0	0	0	0	1,819	1,741	2,983
July	0	0	0	0	0	0	0	369	88	3,208
August	0	0	0	0	0	0	0	1,070	180	308
September	0	0	0	54	0	0	0	1,775	267	9,400
October	107	0	0	0	0	0	0	1,963	856	7,346
November	54	0	0	0	0	0	0	990	996	6,729
December	0	0	0	0	0	0	0	641	1,305	3,231
TOTAL	161	0	0	54	64	0	0	9,467	9,304	37,730

Source: U.S. Bureau of the Census.

Table 6 --United States. Imports of fresh salmon from Iceland, by value and month, 1983-91.

Month	Fresh Imports								
	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00								
January	0	0	7,200	0	0	124,785	75,643	147,426	102,775
February	0	7,500	0	0	0	90,912	134,511	203,287	74,851
March	0	0	0	0	0	221,405	153,240	343,336	154,046
April	0	0	0	0	0	349,682	185,041	493,756	464,588
May	0	0	1,475	59,374	122,954	442,980	359,857	716,310	626,449
June	0	0	0	217,140	259,373	281,668	264,433	860,100	808,412
July	0	0	0	128,987	33,604	153,937	208,392	785,333	472,624
August	0	0	19,480	12,792	89,112	40,290	167,192	554,443	224,757
September	1,913	7,596	0	0	16,298	90,269	270,973	317,384	305,240
October	0	0	0	7,948	23,855	205,148	104,405	441,478	284,053
November	0	0	0	0	48,571	305,954	174,262	229,935	180,353
December	0	14,908	5,562	0	89,457	243,084	240,295	235,434	97,681
TOTAL	1,913	30,004	33,717	426,241	683,224	2,550,114	2,338,244	5,328,222	3,795,829

Source: U.S. Bureau of the Census.

Table 7. --United States. Imports of frozen salmon from Iceland, by value and month, 1986-91.

Month	Frozen Imports					
	1986	1987	1988	1989	1990	1991
	US$1.00					
January	0	0	0	16,569	0	0
February	0	0	0	31,557	20,735	0
March	0	0	0	66,752	9,921	0
April	0	0	0	159,208	16,135	0
May	0	0	0	46,766	41,854	0
June	0	0	0	0	56,789	0
July	8,672	0	0	34,212	43,894	0
August	0	0	0	75,374	48,964	32,802
September	0	0	0	77,289	74,323	7,671
October	0	0	3,969	38,669	87,889	0
November	0	0	0	19,706	0	0
December	0	0	0	20,192	0	0
TOTAL	8,672	0	3,969	586,294	400,504	40,473

Source: U.S. Bureau of the Census.

Table 8. --United States. Imports of smoked salmon from Iceland, by value and month, 1982-91.

Month	Smoked Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	0	0	0	0	1,184	0	0	0	3,938	20,442
February	0	0	0	0	0	0	0	0	4,044	5,661
March	0	0	0	0	0	0	0	4,487	7,591	5,589
April	0	0	0	0	0	0	0	2,594	9,033	24,378
May	0	0	0	0	0	0	0	7,265	39,428	17,068
June	0	0	0	0	0	0	0	28,191	26,150	47,691
July	0	0	0	0	0	0	0	6,789	1,514	52,271
August	0	0	0	0	0	0	0	15,161	3,099	4,866
September	0	0	0	0	0	0	0	22,413	5,065	155,130
October	1,864	0	0	1,071	0	0	0	32,278	12,150	119,609
November	952	0	1,575	0	0	0	0	12,919	16,086	109,548
December	0	0	0	0	0	0	0	11,198	21,781	51,841
TOTAL	2,816	0	1,575	1,071	1,184	0	0	143,295	149,879	614,094

Source: U.S. Bureau of the Census.

Chapter IX
Western Europe

IRELAND

The Irish farmed salmon industry started in 1975 when the first sea cage was installed in Connemara; the first harvest of 10 metric tons followed in 1977. Today Ireland ranks among the world's top ten producers of farmed salmon; the 1991 harvest of farmed salmon was 9,300 metric tons worth $49 million. Despite tremendous growth (or possibly because of this rapid growth), the Irish salmon farming industry faces opposition from citizens groups opposing the establishment of new fish farms. This opposition, as well as a limited number of suitable sites, has encouraged many Irish salmon farmers to invest in offshore facilities. Ireland is a leader in highseas salmon farming. Despite bankruptcies associated with the price decline of 1989-91, the Irish salmon farming industry remains optimistic about the future. Irish salmon farmers expect to harvest 9,500 tons in 1992 and have already started to receive higher prices for their salmon in European markets. Increasing prices are expected to help the industry enjoy a profitable year in 1992. The industry anticipates investing $24 million in salmon farming between 1991 and 1995 and is projecting harvests of nearly 13,000 tons by 1995.

CONTENTS

Figure 1.--Map of Ireland.

I. GENERAL

A. Overview

Ireland ranks among the world's largest producers of farmed Atlantic salmon and is the second largest producer of farmed salmon in the European Community (EC).[1] The 1991 Irish salmon harvest was 9,300 t worth $49 million, a 30 percent increase over Ireland's 1990 production of 6,300 t worth about $38 million.[2] Irish salmon farmers expect to harvest 9,500t in 1992 and 10,000t in 1993[3] and hope that increasing prices will help the industry profit by the end of 1992. The Irish salmon industry generated $23 million in export earnings in 1990 and expects this to increase in 1991-92. The salmon farming industry consisted of 26 firms operating 32 salmon sites and 20 companies rearing smolts. The salmon industry employed 496 people (full- and part-time) in 1990.[4]

B. Government services

The An Bord Iascaigh Mhara (BIM, or Irish Sea Fisheries Board), the Údarás na Gaeltachta (UNG, the agency responsible for dealing with the Gaelic-speaking areas of Ireland), and the Electricity Supply Board (ESB) have been instrumental in the development of Ireland's salmon farming industry. The Government of Ireland (GOI) supports the salmon industry through: (1) advisory services, (2) domestic promotions, (3) export marketing, (4) financial assistance, (5) licensing, (6) research, and (7) veterinary services.[5]

The Water Pollution Act of 1977 was one of the first pertinent regulations enacted. The Act was designed to assure water quality and to regulate access to water by various users. Legislation authorizing the GOI to license salmon farming was issued in the Fisheries Act of 1980 (Section 54). The Act allows the Ministry of Fisheries to designate certain areas where fish farming can legally take place; 16 such sites were designated by 1989. The law also gives fish farmers certain legal rights, including protection against trespass. The Act also made it unlawful for individuals to interfere in the operations of a licensed fish farm.[6] In 1990, Ireland endorsed the EC directive that requires most applicants for a salmon farming license to prepare a detailed environmental impact statement before a license is considered.[7]

1. Advisory services

The BIM, UNG, and ESB are all responsible for assisting Irish salmon farmers seeking information about specific problems in salmon aquaculture. These include advisory services about sites, the latest technology in offshore pens, or export markets. BIM, in particular, offers a wide range of services to individuals seeking assistance or information.[8]

2. Domestic promotions

The BIM has been particularly active in expanding the domestic market for salmon products. BIM promotional events are routinely featured in the Irish press and in television programs. About 4 percent of Ireland's 1990 salmon harvest was sold to the Irish retail trade for direct sales to Irish consumers.

3. Export marketing

BIM is also very active in promoting Irish fish and shellfish products at overseas food shows, such as the ANUGA and SIAL world food shows in Cologne and Paris, respectively. BIM is also present at other shows around the world, including the Boston Seafood Show and many smaller events. BIM produces very high quality brochures describing Irish salmon in a number of languages, including English, French, and German.[9] In recent years BIM has cooperated with the Irish Salmon Growers Association (ISGA) in producing promotional literature featuring Irish salmon.

4. Financial assistance

Financial assistance to salmon farmers in Ireland can be generous. There are 3 sources of financial assistance: BIM, UNG, and the European Economic Community (EC) through their FEOGA grant program. BIM offers 3 funding programs:(1) capital grants of up to 50 percent, (2) grants of 10 percent of fixed assets to commercial projects which qualify for further 40 percent funding from the EC, and (3) bridging loans of up to 20 percent while salmon farmers wait for EC funding following EC approval of a grant proposal. Thus, 30 percent BIM grants are available to salmon farmers in Ireland. UNG offers capital grants of up to 65 percent of capital costs. It approved approximately $5 million in grants to support 56 aquaculture projects by 1987.[10] The National Development Corporation of Ireland has also invested venture capital in a variety of salmon projects.[11] These programs were in place in 1986.[12]

Information about current grant programs is not available. It was also reported that corporate taxes on profits from fish farming were set at 10 percent in the mid-1980s as compared with the normal tax of 50 percent. Under the Business Expansion Scheme, investments in fish farms qualified the investor for tax relief of up to I£25,000 per individual per year.

Investments grants by the Irish Government and the EC in the Irish salmon farming industry were nearly $57 million in 1991.[13] Government assistance was distributed as follows: BIM ($4 million), UNG ($9 million), other Irish Government programs ($1 million), the EC ($16 million), and "share capital" investments ($27 million). This amounts to about 37 percent of the total investment in salmon fisheries which included $153 million in private capital.[14]

5. Licensing

Permits are required to operate a freshwater or saltwater salmon facility in Ireland. The licensing process is long and complicated.[15] For a freshwater hatchery, the Irish Government requires: (1) a fish culture license from the Department of Fisheries and Forestry, specifying species, capacity, right of access to inspectors, obligatory reporting of disease, maintenance of records, and non-obstruction of migratory fish, and (2) planning permission from the local authority specifying permissible levels of water uptake and pollutant emission. For a marine grow-out facility, the government requires: (1) a fish culture license as outlined above; (2) a license under the Foreshore Act of 1933, from the Minister for Communications for any operations relating to sea cages or any structure on the foreshore; and (3) planning permission from local authorities for any building erected above the high water mark. Additionally, where operations are to take place within the limits of a "several" fishery in tidal waters, the written permission of the owner(s) is required.[16] Regional Fisheries Boards are responsible for monitoring and enforcing licensing regulations.

6. Research

The Fisheries Research Center near Dublin and the Salmon Research Trust are instrumental in conducting research into areas of concern to salmon farmers. Investigations are also conducted by an independent research service and diagnostic facility at Galway. Joint research in the 1990s involves cooperation between Hanover University, feed manufacturers, BioResearch Ireland, and the EC as part of the development of new quality standards.[17]

7. Veterinary services

Veterinary services are provided by the Disease Diagnostic Service located at University College in Galway.

C. Government policies

The policy of the GOI has evolved during the past 20 years. Initially the GOI was helpful in studying and supporting the establishment of salmon farms as part of a general move to support aquaculture. In the mid-1980s the GOI provided significant financial assistance to the industry as a means of stimulating employment in isolated areas of Ireland; fish farming was also an important export earner for the, nation and there were many indications that Irish salmon production could generate 4,000 new jobs and contribute $900 million to Ireland's Gross National Product by 1995.[18] In the late 1980's, however, voter anger over the impact of fish farms on Ireland's environment gave the GOI cause for concern. Few expected that opposition to salmon farming would grow so quickly. Now the negative side of fish farming became an issue for the Government.[19] Accordingly, the Minister for State at the Department of the Marine, Michael Noonan, told members of the ISGA's annual conference in Connemara, that the Government would continue to support the industry, but would not support those who felt they had a right to "usurp public waters and rights at will."[20] As part of the GOI's program to control the impact of fish farming, an environmental impact statement assessmentwas required for all new salmon farm licenses.[21] The UNG, responsible for the development of salmon farming in the Irish-speaking areas of the country, also announced that it was revising its policy on expansion in areas where tourism and other interests are involved. Although it reaffirmed its support of aquaculture, the UNG announced that it would place much greater emphasis on environmental responsibilities of fish farmers. It also announced an immediate program to study the industry's method of disposing of waste matter, including packaging and other materials. The UNG stated that it had no wish to jeopardize jobs but felt that future salmon farms would have to recognize the need to deal with the concerns of each community where salmon farms would be built.[22] This was a remarkable departure from previous UNG support to the industry, but it indicated that there was a growing concern within the Irish Government that environmental issues also were significant.

Finally, the GOI's policy towards salmon farming

and wild Atlantic salmon fishing also came under discussion as part of the overall review of salmon farming. Public hearings were held about limiting Irish driftnet fishing of wild Atlantic salmon as part of any program to shut down some salmon farm operations. Ocean ranching was also considered as a possible solution to some of the problems of the industry, but international measures would be required to keep other country's fishermen from harvesting the salmon on the high seas.[23] No further developments on this subject have been reported.

II. PROBLEMS OF SALMON CULTURE

There are a number of problems affecting the development of Irish salmon farming, including salmonid diseases and weather damage, that are common to many North Atlantic farms. The rapid pace of development has generated considerable debate in Ireland and has resulted in a strong "anti-salmon farming" attitude among the citizens of the Emerald Isle. Some of the issues facing Irish salmon farmers are examined below:

A. Disease

Irish salmon farmers in 1989-90, faced high mortalities caused by Infectious Pancreatic Necrosis (IPN, a viral salmon disease that kills young salmon). IPN was particularly deadly in Clew Bay in 1989; many salmon farms switched to raising steelhead trout which are not affected by IPN. IPN can reduce production by 20-35 percent on each infected farm if not controlled.[24] The Irish Government imposed strict import controls, including import bans on live eggs or salmon, or even ungutted salmon, to control this problem. The disease has now been successfully confined to a small number of farms. During 1990, the ISGA launched a research program to study disease control. A total of almost $800,000 in financial support has been committed to this effort. The National Diagnostics Center at University College at Galway is searching for a cure for INP with ISGA funds. Irish feed manufacturers and the EC have also provided funds to this research effort. An epidemiological study into INP is being funded by BIM in cooperation with Queens University in Belfast and the Veterinary Research Laboratory in Northern Ireland. Sudden Death Syndrome (SDS) appeared on one farm in Ireland and resulted in very high mortality. No other farms have been affected by SDS in Ireland. There are no current problems reported with furunculosis in Ireland.

B. Sea lice

Irish salmon farmers have experienced significant problems with sea lice for a number of years. They relied heavily on Nuvan[25] to control the problem and this may have contributed to public concern about the environmental effects of this chemical on areas around salmon farms. Irish fish farmers recently began using an anti-sea lice compound identified as "Ivermectin" as a replacement for Nuvan or Aquagard. The product was designed as a pest control agent for cattle. Irish authorities are concerned about the long-term impact of the chemical on the environment; it is said to kill zooplankton in low concentrations and takes several months to degrade in the sea. The product remains in the flesh of salmon (it is administered in salmon feed) for long periods of time. The ISGA has asked that members who experiment with Ivermectin do so only on smolts. The Irish Department of the Marine is monitoring the experimental use of the product.[26] Irish salmon farmers continue to use Nuvan in their operations and have resisted efforts to ban the chemical, which would have a "disastrous" effect on the industry.[27] The BIM has also worked with the Environmental Sciences Unit of Trinity College to use "cleaner fish" (goldsinny, rock cook, and corkwing wrasses) to rid farmed salmon of sea lice.[28]

C. Weather

Irish salmon farmers have periodically suffered losses due to severe winter storms. A winter storm in 1990 caused nearly $1.3 million in damage to Irish salmon farms. A major storm in January 1991 damaged cages and allowed 350,000salmon to escape. A total of 16 cages washed up on the beach at one County Donegal offshore site.[29] Another massive storm swept through Ireland in January 1992 but did not do as much damage as the previous winter's storm. Bridgestone systems apparently have proven able to withstand 80 to 90 foot waves that break over the farms during severe Irish weather.[30]

D. Public concerns

Irish citizens are vocal in expressing their concerns about fish farming. In Connemara -- the birthplace of Irish salmon farming -- a project involving 8 fish farms cages worth $2 million in investments and representing the creation of 100 new jobs was suspended in 1990 because of public

concerns about fish farming. The public's objection to the project reflects the strong feeling held by many that there are too many problems associated with fish farming.[31] Public concern was so strong in Connemara that "almost every tree and telegraph pole has its skull-and-crossboned poster proclaiming 'No Fin-Fish Farming Here' and 'Nuvan Kills'."[32] The fifth annual conference of the Salmon Growers Association was met by a march of protestors. The demonstrators represented Irish shellfishermen, anglers, hotel owners, fishermen, and concerned citizens angry at the disappearance of wild salmon and sea trout. They also voiced their concern about environmental and tourism-based concerns.[33] Fish farms are no longer going to be allowed to be built near recognized bathing beaches, busy pleasure boat marinas, boat shelters, or navigation channels.[34]

E. Sea trout

Irish anglers are quick to blame salmon farms for poor runs of sea-trout:[35]

> *"It seems rather a coincidence that sea-trout and salmon have declined on the west coast of Scotland and the west coast of Ireland in exactly those areas where fish-farming is taking place."*[36]

Irish scientists noted that many of Ireland's sea trout have been infected with sea lice in recent years. Dr. Ken Whelan of the Salmon Research Agency in Newport expressed the thought that salmon farms may have been the source of these sea lice.[37] The Sea Trout Action Group (STAG), established in 1989 to study the problem, acknowledged that sea lice infestation was part of the problem, but it also identified other possible causes including: forestry operations, peat harvesting, quarrying, exploration and mining, drainage and gravel removal, silage-making, sheep dipping, aerial spraying of fertilizers, herbicides, and other chemicals, domestic and industrial pollution, and excessive grazing on mountain land (which causes erosion and silting).[38] The issue of sea lice, however, continued to attract the attention of the STAG and Irish sportsfishermen as late as 1992.[39]

F. Limited sites

Ireland's salmon farming industry is limited by the availability of suitable sites. The result has been to concentrate farms into large, vertically integrated, smolt/salmon growout farms in a few good sites and to foster the development of offshore facilities. Because of growing opposition to the expansion of inshore or coastal areas, it is unlikely that there will be significant expansion of inshore operations. It is possible that existing facilities could expand their holding capacities, but it is unlikely that they will be allowed to open any new farms. This means that Ireland's fish farming community can only look to offshore facilities for expansion opportunities. Ireland is one of the world's leaders in offshore salmon farming as a result of these constraints.

G. Grilse

Because of warm sea water around the coast of Ireland (caused by the Gulf Stream), there is a tendency for Irish salmon to have a high proportion of grilse (early maturing salmon). These grilse are smaller in weight than salmon that spend 2 years feeding at sea. Irish salmon farms are also characterized by a high proportion of grilse. The incidence of grilse is not entirely without some benefits. Because some countries might want to purchase smaller sized fish (under 3 kg), Ireland would have a natural advantage in producing specialty salmon products. Also, grilse provides cash flow for farmers at certain times of the year.[40]

III. HARVESTS

A. Smolts

Ireland's rivers and streams have a long history as important spawning grounds for Atlantic salmon. The fish has served as an important source of food and sport for generations. Salmonid culture first came to Ireland in the 1860s with the development of special hatcheries for rearing salmon.[41]

The ESB of Ireland was responsible for the development of salmon aquaculture in Ireland. This was due, in part, to the ESB's construction of hydro-electric dams along Ireland's rivers. This construction destroyed many of Ireland's most productive salmon spawning grounds. The ESB was then required to re-stock rivers used to generate electricity; this is how they became involved in salmon aquaculture. Initially the ESB was responsible for establishing and operating four salmon hatcheries.[42] Later, the Salmon Research Trust, funded by the Government of Ireland and the Guiness Foundation, established a salmon smolt hatchery in County Mayo. The facility was used to restock rivers and to sell smolts to salmon farmers.[43]

There were 10 smolt grow-out facilities operating in Ireland by 1987. The ESB operated 4 of these facilities, and output amounted to 650,000 smolts in 1987. Expansion was planned for the industry, but opposition from fishermen's groups delayed or halted the project. In addition, Irish salmon farmers imported salmon smolts from Iceland, Norway, and Scotland in 1987.[44] In 1991, there were 22 companies raising smolts in Ireland. There are 10 independent companies raising smolts and 12 companies raising smolts and salmon. Most sea-site farmers have their own smolt raising facilities. Smolt product was 8.6 million in 1991 compared to 7.8 million in 1990 and 7.4 million in 1989. Irish smolt production is projected at 9 million in 1992.[45]

B. Salmon grow-out farms

1. Historic, 1973-80

Ireland's salmon farming industry owes its origins to a fact-finding mission to Norway organized by the ESB and BIM in 1973. The trip prompted BIM and ESB to establish salmon farms in Connemara in 1974-75. The BIM facility was not successful as mussels formed on the netting of the pen in Killary Harbor.[46] The ESB facility was successful, and it was able to harvest 10 tons of farmed salmon in 1977.[47] ESB has since established fish farms throughout Ireland, and it's **Salmara Teo** is an important salmon producing operation.[48] By 1980, the Irish harvest was 21 tons.

2. Offshore, 1983

Ireland's first offshore salmon grow-out facility, a Bridgestone Hi-Seas floating fish cage, was imported from Japan in 1983. Ireland has since invested heavily in the Bridgestone system which feature large, rubber cages able to withstand heavy seas. Each system can hold 100 t of fish. The first Swedish-built Farmocean semi-submersible fishing farming cage was started in 1987.[49] Bradan Mara Teo, the owner, anchored the Farmocean system off Connemara, where the first salmon had been harvested only a decade earlier.[50] Irish-Norwegian joint venture business partners, of the **Brandan Ur Atlantach Teoranta** (Fresh Atlantic Salmon Ltd), with support from UNG, imported the first offshore fish barge from Norway in 1989.[51] The facility, called *Bradan Feasa*,[52] was moored in Galway Bay and included 12 pens with a total capacity of 25,000 cubic meters able to hold up to 700 tons of mature salmon annually.[53] Unforuntately, this farm proved uneconomic and has since gone out of business. Technological developments in offshore cage construction, including the development of flexible, high performance rubber cages, hinged cages, semi-submerged units, and vessel-shaped farms, has made Ireland the world's leader in offshore aquaculture. The most successful offshore pen systems are Bridgestone (54 cages in 1990). Other systems (which also hold steelhead trout) include Wavemaster, Steelform, Polar Circle, Kames, and a smaller, flexible Tempest system developed by Dunlop. There were 893 cages (salmon and trout) with a total capacity of 1.4 million cubic meters in Ireland in 1990.[54]

One important benefit from offshore farms is that the ocean currents forces the fish to swim constantly. Micheal Kennedy of the Irish Salmon Producers' Group states: "We estimate {that the fish swim} up to 100 kilometers a day -- so their flesh is very firm with good texture."[55] This is especially important to smokers because these fish cut very well. "They also have a lower fat content -- eight to 12 percent -- becuase they are exercising and have good flesh tone with their colour pigment spread evenly throughout the body."[56]

3. Joint-ventures, 1984-86

Norwegian legislation limiting the size of salmon farms in Norway prompted many enterprising Norwegian fish farmers to look abroad for new opportunities. Ireland attracted a number of Norwegian investors in the mid-1980s. **Fanad Fisheries** in Donegal became a major farmed salmon producer thanks to a joint venture operation with Mowi of Bergen, Norway. **Timar Aqua,** which operates 3 farms, is another joint venture operation with Norwegian expertise.[57] Other joint venture salmon farming operations established in Ireland include: **Ocean Farm** in Donegal, **Erin-Or** in Kerry, and **Bradan Ur Atlantach,** which includes 5 Norwegian partners.

4. Rapid growth, 1985-88

Ireland had 10 salmon farms producing a total of 700 t of salmon in 1985. Harvests increased dramatically during the next few years, reaching 4,200 t in 1988. High prices for farmed salmon on world markets stimulated much of the investment in salmon farming through 1989. Some also attribute the growth of salmon farming in Ireland to the need to supplement wild salmon catches.[58] As wild salmon catches began dwindling, the value of farmed salmon increased. Irish smokers quickly became avid users of farmed salmon; whereas wild salmon landings were

erratic and declining, farmed salmon could be supplied as needed throughout the year. This resulted in reduced inventories for smokers and produced a higher quality smoked fish. Irish smokers are an important domestic market for salmon farmers and help maintain Irish sales.

5. Bankruptcies, 1989-91

Irish salmon farmers harvested about 5,200 t in 1989, but problems were beginning to threaten this thriving industry. Norwegian salmon farmers were also harvesting increasing quantities of salmon, but the quantities were so great that prices began to decline as Norwegian exporters were unable to maintain an orderly flow of product to world markets. Irish salmon farmers faced increasing difficulties maintaining their market shares, and several bankruptcies hit the Irish salmon industry. **Camus Salmon Holdings** and **Bradan ur Atlantach** both declared bankruptcy and were forced to liquidate their holdings. Another large firm, **Bradan na Ceathra Rua Teo**, declared bankruptcy in April 1991. Bradan a Ceathra had produced 100 t per annum and had a license to produce 500 tons. These financial difficulties made capital increasingly scarce as banks lost faith in the salmon culture industry and tightened up their lending practices. The Irish-Norwegian joint venture, **Brandan Ur Atlantach Teoranta (Fresh Atlantic Salmon Ltd)** announced that it was going bankrupt in 1991. The company had lost about $1.5 million worth salmon during a storm and had not received anticipated EC grants in a timely manner. These factors, combined with cash flow problems and growing competition from Norwegian exports to Europe, brought the company into receivership.[59] Despite all the difficulties, the Irish harvest of farmed salmon reached an estimated 9,300 t worth $49 million in 1991.

6. Turning point, 1992

Irish salmon farmers are reasonably optimistic about the future. The EC reacted to their complaints about alleged Norwegian salmon dumping by imposing minimum price guides on salmon entering the EC market in late 1991-92. This helped control the decline in EC salmon prices and permitted Irish salmon farmers to begin their recovery.[60] The decision of the U.S. Government to impose anti-dumping and subsidy duties on imported fresh, Norwegian farmed salmon allowed Irish exporters a rare opportunity to expand their markets in the United States (albeit in competition with U.S., Chilean, and Canadian salmon farmers). The Norwegian salmon farming industry, badly disrupted by overproduction, has taken steps to limit production: the harvest for Norwegian salmon for 1992 is projected at 120,000 tons. This is nearly 30,000 tons below comparable 1991 production. Many salmon producers now anticipate an increase in salmon prices to occur in late 1992. Irish salmon producers have already reported increasing prices and expect to generate profitable returns during 1992.[61]

IV. ASSOCIATIONS AND COMPANIES

A. Associations

The Irish Salmon Growers Association was established in 1988 to represent the interests of Irish salmon farmers. It included 37 members by 1989. The ISGA has its headquarters in the Farm Centre, Naas Road, Bluebell, Dublin. A Board of Directors elected by members controls the ISGA. The Association arranges for the transportation of salmon from farms to packing stations and serves as a marketing agent for some of Ireland's smaller salmon farmers.

B. Companies

Three of Ireland's salmon growers account for nearly 55 percent of the nation's total sales of farmed salmon. These 3 firms market their own products.

The **Irish Salmon Producers Group (ISPG)**, is the largest single marketing company in the Irish salmon industry. The ISPG was established in 1985 with 12 salmon-producing companies as its members.[62] The Group represents 13 salmon and trout farms (including 6 offshore salmon sites) and operates a central processing and distribution plant in Connemara, Ireland. The ISPG had output of fresh

salmon during 1991 of over 3,000 t, 40 percent of the total Irish output. The ISPG expects its output to rise to 4,000 t during 1993.[63] ISPG markets its products under the *Bia Mara* label, which is the leading export brand for Irish farmed salmon. The ISPG has representatives in the United States and Europe and concentrates its marketing efforts towards France, Belgium, Luxembourg, Spain, and the United States.

P.J. Carroll & Company, owners of **Carroll Seafood**, left the Irish salmon culture business during 1991. Carroll owned 3 salmon hatcheries, 3 fish farms, and two processing plants which employed over 100 people. The fish farming side of the operation produced over 2,000 t of farmed Atlantic salmon annually, which represents fully one fourth of total Irish farmed salmon production.[64] In addition, Carroll's smolt facilities produced over 1.1 million smolts during 1990. Most of this production is marketed under the *Bradan Mara* label. **Gaelic Seafoods Ltd.**, a British-based company, purchased the businesses involved during December 1991 as going concerns. This saved the Irish industry from the terrible blow which the loss of the Carroll Seafood output and employment would have caused. Following the purchase, therefore, Gaelic becomes the second largest producer in the Irish salmon industry.

The Economic and Social Research Institute (ESRI) in Ireland has studied the profitability of the Irish salmon industry in considerable detail.[65] The ESRI reported that the value of all salmon and trout farms, including cages, rafts, nets, boats, vehicles, and buildings, was worth nearly $58 million out of a total aquaculture industry worth almost $75 million. The study concluded that salmon farming in 1990 was generally unprofitable. The study reported that 4 farms reported profitable operations in 1990, 7 operated at a "break-even" level and 4 reported losses. The report noted that salmon farming does offer one of the few areas remaining for development in Ireland's western coast. Tourism, although important, is seasonal. Capture fisheries are important to the region, but in view of the EC's Common Fisheries Policy, it is unlikely that Irish quotas will be increased in the future. Thus, aquaculture remains an important area for future development.[66]

V. EXPORTS

Irish exports of farmed salmon were valued at $27 million in 1991 compaed with $23 million in 1990 and $20 million in 1989 (see Appendix C, Tables 1 and 2).

France remains Irish salmon growers' most important market, absorbing more than half of Ireland's total salmon production.[67] In 1990, the Irish shipped 2,600 t of fresh salmon (62% by quantity) worth $13.5 million (59% by value) to France. This compares with 2,700 t (73 percent) worth $13.5 million (65% by value) in 1989.[68] French consumers like salmon in the 1-2 and 2-3 kg range, and Ireland produces a high percentage of these smaller sized salmon.

The **United States** market absorbs about 15 percent of Ireland's salmon production. Ireland has a long tradition of exporting smoked salmon to the U.S. market; exports were 43 t worth $0.7 million in 1991. Exports of fresh salmon began in 1983 when a small shipment was made. Exports increased sharply in 1988 when over 300 t worth $.26 million were shipped (Appendix section). Irish exports of salmon peaked at $3.4 million in 1990 and then declined by nearly $0.6 million to $2.8 million in 1991. Although the value of exports declined, the quantity exported increased from 401 t in 1990 to 411 t in 1991. This meant that Irish exporters were receiving nearly 18 percent less for their salmon than during 1990. The decline in Irish sales is particularly evident when looking at U.S. monthly imports (Tables 4 and 6) which show a dramatic decline in shipments starting in July 1990 and culminating in September 1991 when imports ceased. The decline in the value of Irish salmon exports is attributed to a "recession" in the United States, and particularly in the food service industry where larger volumes and tighter margins were needed in 1991.[69] Irish exporters, however, are optimistic about expanding their markets in the New York area without competition from Norway. This was the result of U.S. import duties on fresh Norwegian salmon in 1991.

Spain became Ireland's 3rd largest customer in 1990. **West Germany** and the rest of Europe import about 8 percent of Ireland's salmon harvests, and **Japan** imports about 2 percent.

One important event in Ireland's program to export farmed salmon was the problem it faced with lower world prices beginning in 1989 and lasting until mid-1992. The ISGA, in cooperation with Scottish salmon farmers, were vocal in demanding action from Irish and EC authorities to stop the alleged dumping of Norwegian salmon on EC markets. They were successful in this appeal and were ultimately rewarded by the EC imposing minimum import prices on fresh salmon in late 1991.[70] This allowed the Irish to begin their recovery and is one reason why the Irish anticipate a profitable year in 1992.

Ireland exports a large percentage of its farmed salmon as head-on gutted fish, fillets, steaks and smoked product.[71] Because most Irish salmon is reared offshore in relatively exposed waters, it is often marketed as "semi-wild."[72] Some salmon imported into Ireland is being re-exported as "Irish smoked salmon". There is some consumer confusion between "smoked Irish salmon" and "Irish smoked salmon" that worries Irish salmon producers who fear that lower-quality products might damage the reputation of Irish farmed salmon.[73]

VI. OUTLOOK

Irish producers are cautiously optimistic about 1992, due to a slight increase in European prices and relatively low mortality during 1991. If they can continue to increase their yield and efficiency through controlling disease and carefully managing farming enterprises, Irish salmon farmers should be able to expand production during 1992 and turn a profit. Though the bankruptcies of the late 1980's and early 1990's are a sign of deep trouble in the Irish industry, the remaining firms are determined to stay with the business. The Irish salmon farming industry plans to invest approximately $24 million in fixed capital over the next five years, and they hope to see salmon production reach 13,000t by 1995.

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_____, "Sea Lice May Not be only Factor In Trout Decline, Say Scientists," *Irish Times*, August 6, 1990.

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Exchange rates:
(Irish pounds to U.S. dollars and dollars to Irish pounds):

I£1.00 = $1.00	$1.00 = I£1.00
1991 = $1.61	1991 = I£0.62
1990 = $1.65	1990 = I£0.60
1989 = $1.41	1989 = I£0.70
1988 = $1.55	1988 = I£0.65
1987 = $1.60	1987 = I£0.62
1986 = $1.35	1986 = I£0.74
1985 = $1.07	1985 = I£0.93

ENDNOTES

SECTION I (General)

1. Scotland is the largest EC producer. Other EC salmon producers include Spain and France.

2. U.S. Embassy, Dublin, June 17, 1992.

3. U.S. Embassy, Dublin, June 17, 1992.

4. U.S. Embassy, Dublin, June 17,1992and R. O'Connor, B.J. Whelan, J.A. Crutchfield, and A.J. O'Sullivan, *A Review of the Irish Aquaculture Sector and Recommendations for its Development,"* Executive Summary, The Economic and Social Research Institute, General Research Series, Paper No. 156, Dublin, 1991.

5. "Executive Summary," *The Atlantic Salmon Farming Industry: Past Performance and Future Potential,"* An Bord Iascaigh Mhara, Dublin, October 1986, p.20.

6. Justin McDonnell, "Fish Farmers Get Benefits of Legal Protection," *The Irish Skipper*, October 1983 and "Aquaculture Sites Named in Ireland," *Fish Farming International*, February 1987.

7. U.S. Embassy, Dublin, June 17, 1992.

8. These services are explained each year in the BIM's *Annual Report and Accounts*.

9. "From the Clear Atlantic Waters of Ireland" is a glossy brochure published by BIM in English, French, and German. The publication features some excellent photography and is very well designed.

10. This includes aquaculture in salmon farming and other aquaculture projects. Gaeltacht Board Growth Industry," *Fish Farming International,* June 1987, pp. 14-15.

11. The National Development Corporation has recently been merged with the Industrial Development Authority and no longer invests funds in the aquaculture industry.

12. "Executive Summary," *The Atlantic Salmon Farming Industry: Past Performance and Future Potential,"* An Bord Iascaigh Mhara, Dublin, October 1986, p.20.

13. It is not clear whether this amount represents the total amount granted since the industry began in the 1970s or if this covers the period since 1980 or if this represents a recent funding period.

14. U.S. Embassy, Dublin, June 17, 1992 and R. O'Connor, B.J. Whelan, J.A. Crutchfield, and A.J. O'Sullivan, *A Review of the Irish Aquaculture Sector and Recommendations for its Development,"* Executive Summary, The Economic and Social Research Institute, General Research Series, Paper No. 156, Dublin, 1991, p.123 for earlier investment figures.

15. "Executive Summary," *The Atlantic Salmon Farming Industry: Past Performance and Future Potential,"* An Bord Iascaigh Mhara, Dublin, October 1986, p.20.

16. U.S. Embassy, Dublin, May 29, 1987.

17. *Salmon Farming: Building Ireland's Newest Marine Industry*, a cooperative publication of the Irish Salmon Growers Association and the An Board Iascaigh Mhara, Dublin, (no date).

18. These figures were attributed to Dr. John Joyce, Chief Executive of the Irish Salmon Growers Association in "Salmon Farming...A Growth Industry, *Irish Independent*, April 3, 1990.

19. "Salmon Review Could Threaten Drifters - Public Seeks Policy Change," *The Irish Skipper*, February 1990.

20. "Fishfarms Told: Cure Own Problems," *The Irish Skipper*, November 1990.

21. "Ireland: An Industry Under Siege," *Fish Farmer*, September/October 1990, p.41.

22. "Udaras Revises Fishfarm Policy," *The Irish Skipper*, June 1990.

23. "Salmon Review Could Threaten Drifters: Public Seeks Policy Change," *The Irish Skipper*, February 1990.

SECTION II (Problems of Salmon Culture)

24. Robert O/Connor, "Country Reports: Ireland," *Salmon Market Newsletter*, June, 1990, p. 5.

25. The active ingredient of this chemical is dichlorovos.

26. "New farmed Salmon Treatment Causes Concern," *Seafood International*, February 1991, p. 16.

27. Lorna Siggins, "Fish-Farming Industry Study Urged," *Irish Times*, August 6, 1990.

28. "Irish Fishermen Help to Find Cleaner Fish," *Fish Farming International*, October 1991, p. 26.

29. The U.S. Embassy reports that the Bridgestone cages withstood the storms with the least amount of damage. "Seafarms Hit by Storms," *The Irish Skipper*, March 1991 and U.S. Embassy, June 17, 1992.

30. Reported by Michael Kennedy, of the Irish Salmon Producers' Group in an article entitled "Irish Salmon Farmers' Venture Promises 4000 Tonnes This Year," *Seafood News*, May 1992, p.22.

31. "Salmon Farming Concerns Expressed," *Irish Times*, May 9, 1990.

32. Steenie Harvey, "Gold: An Unwelcome Prospect for Ireland?" *World Fishing*, August 1990.

33. Catherine Foley, "Protest over increase in Salmon Farms," *Sunday Tribune*, October 14, 1990.

34. R. *O'Connor, B.J. Whelan, J.A. Crutchfield, and A.J. O'Sullivan, A Review of the Irish Aquaculture Sector and Recommendations for its Development,"* Executive Summary, The Economic and Social Research Institute, General Research Series, Paper No. 156, Dublin, 1991, p.4.

35. The European Community Labelling, Presentation and Advertising of Foodstuffs Regulations define what is allowed to be used in the sale of food products. The term "sea trout" may be applied only to the species *Salmo trutta* (called brown trout in the United States) which has spent part of its life in seawater. The proper name for *Salmo gairdneri* is "rainbow trout" and the legislation does not distinguish between rainbow trout grown in freshwater or seawater.

36. Attributed to Will Hollinger, a Northern Ireland businessman in an article written by Richard Douthwaite, "Anglers Fear Fish-Farms in West are Killing Wild Salmon," *Irish Times*, July 22, 1990.

37. Richard Douthwaite, "Anglers Fear Fish-Farms in West are Killing Wild Salmon," *Irish Times*, July 22, 1990.

38. Lorna Siggins, "Sea Lice May Not be only Factor In Trout Decline, Say Scientists," *Irish Times*, August 6, 1990.

39. The STAG recently identified the Killary Salmon farm as being responsible for infecting wild stocks of sea trout with sea lice in the area around Delphi and Erriff in western Ireland. The STAG claimed that 94 percent of sea lice in the area originated from salmon farms. The Irish Salmon Growers' Association (ISGA), however, proved that the Killary Salmon farm did not have any smolts or salmon during the migration of the steelhead into the area. All salmon introduced by the Killary Salmon farm since then were completely free of salmon lice. "Irish Fish Farmers Deny Infecting Sea Trout," *Eurofish Report*, June 18, 1992, p. FS/3.

40. "Executive Summary," *The Atlantic Salmon Farming Industry: Past Performance and Future Potential,* "An Bord Iascaigh Mhara, Dublin, October 1986, p.20.

SECTION III (Harvests)

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42. "Executive Summary," *The Atlantic Salmon Farming Industry: Past Performance and Future Potential*, An Bord Iascaigh Mhara, Dublin, October 1986, p.19.

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45. U.S. Embassy, Dublin, June 17, 1992.

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48. "Salmon Among Top Exports," *Fish Farming International,* May 1989.

49. Tom Wray, "Large Irish Salmon Farm Starts Offshore in a Cage Barge," *Fish Farming International,* August 1989, pp.10-11.

50. Tom Wray, "Large Irish Salmon Farm Starts Offshore in a Cage Barge," *Fish Farming International,* August 1989, pp.10-11.

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52. This is the Gaelic for "salmon of wisdom" from an ancient Irish legend. "Ship-shaped Farm Towed to Ireland," *Fish Farming International*, February 1989.

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55. Reported by Michael Kennedy, of the Irish Salmon Producers' Group in an article entitled "Irish Salmon Farmers' Venture Promises 4000 Tonnes This Year," *Seafood News*, May 1992, p.22.

56. Reported by Michael Kennedy, of the Irish Salmon Producers' Group in an article entitled "Irish Salmon Farmers' Venture Promises 4000 Tonnes This Year," *Seafood News*, May 1992, p.22.

57. "Salmon Among Top Exports," *Fish Farming International,* May 1989.

58. U.S. Department of Commerce, *Aquaculture and Capture Fisheries: Impacts in U.S. Seafood Markets, 1988*, p. 85.

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60. Many Irish salmon farmers would disagree, claiming that the minimum prices were set too low. Many farmers want future minimum salmon reference prices to be based on the cost of production, plus a 10-15 percent allowance for profits.

61. "Optimism Returns to Irish Aquaculture," *Eurofish Report*, December 19, 1991, p. FS/3.

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63. ISPG director Michael Kennedy is quoted in *Seafood International,* April 1992, p. 25

64. "Bad Markets Drive Out Irish Salmon Farmers," *The Irish Skipper,* May 1991, p. 3.

65. *O'Connor, R., B.J. Whelan, J.A. Crutchfield, and A.J. O'Sullivan, A Review of the Irish Aquaculture Sector and Recommendations for its Development,"* Executive Summary, The Economic and Social Research Institute, General Research Series, Paper No. 156, Dublin, 1991.

66. *O'Connor, R., B.J. Whelan, J.A. Crutchfield, and A.J. O'Sullivan, A Review of the Irish Aquaculture Sector and Recommendations for its Development,"* Executive Summary, The Economic and Social Research Institute, General Research Series, Paper No. 156, Dublin, 1991.

SECTION V (Exports)

67. "Optimism Returns to Irish Aquaculture," *Eurofish Report*, December 19, 1991. p. FS/3.

68. U.S. Embassy, Dublin, June 17, 1992.

69. "Irish Fish Exports to US Show 'Recession' Drop," *The Irish Skipper,* June 1992, p.12.

70. As indicated, many Irish salmon producers would have preferred higher minimum import prices.

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Appendix C

Ireland

Table 1.--Ireland. Farmed salmon industry, 1977-91.

Year	Smolt production	Salmon harvests			Fresh farmed salmon exports		Number of farms	Employment
		Quantity	Value		Value			
	Millions	*Metric Tons*	*I£1,000*	*US$1 Million*	*I£1,000*	*US$1 Million*	*Number*	
1977		10	33	-		-	1	
1978		20		-		-	1	
1979				-		-	1	
1980		21	73	-		-	4	
1981		35	122	.1	126	.2	3	
1982		100	350	.5	360	.6	8	
1983		257	1,042	2	817	1	8	
1984		385	1,799	3	1,347	2	8	
1985		700	3,150	3	2,385	3	11	
1986		1,215	4,540	6	4,300	6	13	
1987	.7	2,232	10,122	16	7,775	12	17	
1988		4,075	19,500	30	10,873	17	19	
1989	7.4	5,196	21,750	31	14,551	20	22	
1990	7.8	6,323	22,100	36	13,746	23	22	496
1991	8.6	9,300	30,253	49	16,594	27	26	

Source: U.S. Embassy, Dublin (harvests and exports for 1990 and 1991 and value in US$1 million for 1989-91). Pat Keogh, Deputy Chief Esecutive, An Bord Lascaigh Mhara,Dublin, Ireland, fax message dated July 27, 1992 for all data on landings and value (Irish pounds) and number of farm sites. Mr. Keogh noted that these figures were for fresh salmon production in Ireland.

Table 2.--Ireland. Exports of fresh salmon, 1987-90.

Country	Quantity				Value			
	1987	1988	1989	1990	1987	1988	1989	1990
	Metric Tons				US$1,000			
France	1,124	1,610	2,715	2,582	7,206	10,927	13,539	13,500
United States	41	267	474	401	411	2,345	3,452	3,389
Spain	75	46	30	607	552	316	578	2,459
Japan	17	21	5	107	181	141	41	856
N. Ireland	-	-	267	153	-	-	1,228	578
Germany, FRG	9	4	48	61	73	52	313	483
Benelux	63	55	80	58	519	433	556	431
Netherlands	27	128	74	51	218	1,053	525	360
Great Britain	365	185	13	106	2,238	1,238	79	243
Switzerland	2	2	3	.3	22	12	4	3
Italy	-	-	10	.5	-	-	48	2
Canada	-	-	-	.1	-	-	-	2
Others	10	1	3	1	90	8	121	376
TOTAL	1,733	2,319	3,722	4,128	11,510	16,525	20,484	22,682

Source: U.S. Embassy, Dublin.

Table 3.-- United States. Imports of farmed salmon from Ireland, 1983-91.

Year	Quantity		Total quantity	Value		Total value
	Fresh	Smoked		Fresh	Smoked	
	Metric Tons			*US$1,000*		
1983	.3	25	25	3	416	419
1984	-	28	28	1	400	401
1985	13	17	30	108	265	373
1986	21	15	36	181	272	453
1987	47	14	61	395	269	664
1988	310	14	324	2,578	212	2,790
1989	427	36	463	2,955	643	3,598
1990	356	45	401	2,604	799	3,403
1991	368	43	411	2,145	689	2,834

Source: U.S. Bureau of the Census.

Table 4. --United States. Imports of fresh salmon from Ireland, by quantity and month, 1983-91.

Month	Fresh Imports								
	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms								
January	0	0	0	0	0	0	17,489	38,945	1,800
February	0	0	0	0	0	6,386	37,866	41,431	34,846
March	0	0	897	4,323	982	17,240	76,251	72,919	117,469
April	0	44	0	6,567	017,348	28,043	88,289	85,921	118,776
May	48	0	6,629	8,797	14,844	31,650	76,235	48,711	69,629
June	49	0	4,472	465	9,308	24,698	35,468	43,121	14,273
July	184	0	1,501	0	01,640	12,518	14,792	8,752	10,593
August	29	0	0	260	0	51,730	14,891	4,103	608
September	0	0	0	0	0	41,253	11,874	6,472	0
October	0	0	0	0	1,548	29,593	10,443	2,308	0
November	0	0	0	307	804	21,624	18,696	2,961	0
December	0	0	0	0	164	44,908	24,635	270	0
TOTAL	310	44	13,499	20,719	46,638	309,643	426,929	355,914	367,994

Source: U.S. Bureau of Census.

Table 5. --United States. Imports of smoked salmon from Ireland, by quantity and month, 1982-91.

Month	Smoked Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	2,348	1,834	2,858	1,266	1,593	886	707	2,433	2,146	607
February	927	1,443	1,390	1,121	617	1,571	321	3,275	2,120	2,303
March	1,078	891	2,006	1,595	751	1,050	1,850	2,592	5,735	3,312
April	664	1,534	4,026	1,344	943	1,035	295	2,827	3,996	1,837
May	630	2,454	1,852	725	1,016	1,318	1,910	2,810	4,012	2,002
June	377	551	2,544	971	668	1,010	561	3,212	2,780	5,488
July	1,468	391	1,816	1,975	2,103	1,344	1,441	1,595	2,516	3,177
August	1,332	3,147	1,911	1,814	971	521	465	1,246	1,165	6,265
September	866	2,026	1,874	1,181	1,884	445	657	1,826	2,460	1,748
October	622	2,827	2,059	1,019	1,216	1,953	1,732	3,488	10,921	4,712
November	3,284	3,287	1,444	2,036	747	1,933	2,561	4,803	4,043	8,381
December	1,849	4,222	3,769	2,107	2,520	585	1,621	6,003	3,226	3,445
TOTAL	15,444	24,607	27,549	17,154	15,029	13,651	14,121	36,110	45,120	43,277

Source: U.S. Bureau of the Census. Note: These smoked salmon presumably include farmed Irish salmon, wild Irish salmon, and wild and/or farmed salmon imported into Ireland where the product is smoked, and then re-exported as Irish smoked ssalmon.

Table 6 --United States. Imports of fresh salmon from Ireland, by value and month, 1983-91.

Month	Fresh Imports								
	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00								
January	0	0	0	0	0	0	140,022	266,209	11,874
February	0	0	0	0	0	53,666	276,965	314,149	0
March	0	0	5,500	38,916	8,448	154,752	518,605	538,821	211,622
April	0	887	0	060,235	133,904	236,157	594,520	629,072	689,728
May	523	0	52,573	73,367	122,970	276,560	554,930	357,746	684,410
June	535	0	36,955	4,104	86,685	211,813	258,017	307,569	410,061
July	2,030	0	13,017	0	16,007	112,639	102,411	65,634	76,618
August	325	0	0	2,004	0	435,278	81,473	25,926	56,006
September	0	0	0	0	0	350,427	80,257	50,164	4,683
October	0	0	0	0	16,901	244,618	72,032	19,272	0
November	0	0	0	2,440	7,816	179,606	116,146	27,145	0
December	0	0	0	0	2,649	322,944	159,816	1,943	0
TOTAL	3,413	887	108,045	181,066	395,380	2,578,460	2,955,194	2,603,650	2,145,002

Source: U.S. Bureau of the Census.

Table 7. --United States. Imports of smoked salmon from Ireland, by value and month, 1982-91.

Month	Smoked Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	34,783	25,115	41,760	20,337	28,219	16,056	12,851	44,106	39,099	9,518
February	15,610	24,156	21,557	16,894	11,271	29,264	6,678	59,814	38,078	56,826
March	15,407	13,618	29,257	23,618	14,965	21,184	38,034	49,966	114,815	55,692
April	11,134	23,899	52,641	22,367	18,791	18,871	5,212	50,751	54,280	34,029
May	10,218	39,064	25,156	9,808	12,878	25,917	32,554	48,811	76,818	35,766
June	6,774	8,719	32,412	15,880	14,836	19,329	9,701	58,153	54,185	73,451
July	22,351	6,907	26,041	30,328	37,024	26,770	26,091	21,478	47,244	48,658
August	21,492	49,966	28,467	27,738	16,791	11,097	9,594	19,555	24,785	97,780
September	12,777	33,732	27,769	19,464	34,299	9,493	8,528	29,990	45,879	23,433
October	9,932	47,888	31,501	14,263	20,752	38,656	20,259	64,130	181,100	75,532
November	56,149	65,977	22,689	33,937	15,338	37,295	19,044	91,847	71,860	134,262
December	32,619	77,039	60,400	30,405	47,184	14,698	23,386	103,973	51,326	43,691
TOTAL	249,246	416,080	399,650	265,039	272,348	268,630	211,932	642,574	799,469	688,638

Source: U.S. Bureau of the Census.

Chapter IX
Western Europe

NORWAY

Norway is the world's leading producer of farmed salmon, specializing in raising the highly prized Atlantic salmon (*Salmo salar*). Norwegian salmon farmers pioneered the art of producing a superior salmon product and now account for over half of the world's farmed Atlantic salmon. Norway's harvests of salmon increased from 84,000 metric tons in 1988 to a record 158,000 tons in 1991. The problem with this harvest was not the quantities produced, but rather that it overwhelmed the ability of the Norwegian Fish Farmers' Sales Organization to maintain a steady flow of high-quality product to customers around the world. The increase in harvest between 1989 and 1990, for example, amounted to nearly 43,000 tons -- which is more than the entire production of Scotland! The harvests were so great that prices declined to levels that could not sustain farm profitability. The Norwegian Fish Farmers' Sales Organization in 1990 purchased and froze some of the excess harvest, but the attempt failed to stem the flow of harvested product. The Fish Farmers' Sales Organization, which had controlled Norway's farmed salmon exports for nearly 2 decades, declared bankruptcy in late 1991. Complicating the supply problem, the principal importers (the European Community and the United States) took steps to restrict imports of Norwegian salmon, further disrupting the Norwegian salmon farming industry.

Norway's marketing problems can be traced to two actions by the Norwegian Government: (1) liberalizing the growth of the salmon smolt industry in 1985, and (2) increasing the pen volume farmers are allowed from 8,000 cubic meters to 12,000 cubic meters in 1988. The Norwegian Government's actions were the result of political pressure by investors anxious to profit from the tremendous returns reported by farmers in 1986 and 1987. In retrospect, the Norwegian Government's decisions appear to have inflamed the "boom" mentality among Norwegian bankers, investors, smolt producers, and fish farmers, stimulating investments and over capacity in salmon farming and overwhelming the ability of the industry to market the increasing harvests in an orderly fashion.

Consumer demand for a luxury seafood at bargain prices helped mask the seriousness of the problem -- and consequently delayed constructive action to control the situation -- until nearly 2 years into the crisis. Expanding sales created the impression that demand would continue to outpace production. This stimulated smolt and salmon farmers to keep producing, when a more prudent policy would have dictated reducing harvest. At the same time Norwegian salmon farms were increasing harvests, farmers in Scotland, Canada, Iceland, Chile and other countries were also expanding their harvests. Competition intensified as salmon producers from around the world struggled to maintain markets at steadily deteriorating prices. The result was a downward price spiral that culminated in Norway's massive farmed-salmon freezing scheme and the 1991 bankruptcy of the Fish Farmers' Sales Organization. As a result of the crisis, everyone (from farmers to bankers to the government) now realizes the importance of controlling the growth of the industry to the available market to maintain prices. Most farmers that delivered product to the Fish Farmers' Sales Organization for export will be lucky to receive $0.47 to $0.70 on the dollar following the Organization's collapse. The short-term impact is likely to result in lower harvests for the next few years. The industry has cut back smolt production and the 1992 salmon harvest is expected to decline to about 120,000 tons. In summary, the Norwegian industry is emerging from a serious crisis badly shaken, but is now leaner and is beginning to focus on the future.

CONTENTS

Introductory Remarks

The problem of soaring harvests and market disruption is a very serious issue in Norway. Many individuals and companies have suffered economic losses or bankruptcy. This report does not attempt to assign blame, but rather attempts to learn the causes of this problem and to identify possible future directions that the industry might take. The author has attempted to describe the situation in Norway's salmon industry as factually as possible. A variety of interpretations are possible and the author has attempted to provide a full range of the various assessments.

Acknowledgements

I wish to acknowledge the full cooperation of the Royal Ministry of Fisheries and the Counselor of Fisheries at the Royal Norwegian Embassy in Washington, D.C. Their assistance reflects the "openness" that the Government of Norway has in dealing with this sensitive subject. Their support of my visit to Norway during the week of May 11-14, 1992 is especially appreciated.

I. OVERVIEW

A. Special features

Norway has a number of unique features that have allowed it to become the world's top producer of farmed Atlantic salmon. These include:

Protected coast: A 21,000 kilometer (km) coastline dotted with many islands and laced with deep fjords that protect fish farms from severe winter weather.

Extensive sites: Approximately 70,000 square km available for fish farming, nearly eight times Norway's available area for land-based agriculture.[1]

Available work force: Communities along the length of the nation's 21,000 km coastline permit the extensive utilization of suitable locations with only limited conflicts with competing economic activities.

Favorable temperatures: Relatively warm coastal water temperatures (5° to 12° Celsius) caused by the Gulf Stream with a 6.9 pH, nearly perfect for growing salmon.

Fresh water: Snow-fed rivers provide ample quantities of fresh water needed to raise smolts.

Abundant feed: Norway's coastal waters contain large quantities of small pelagic fish for producing fish feed. Norway's capelin, sand eel, and Norway pout resources, in particular, are an excellent source of high protein fish meal.

Established fisheries: Norway has many efficient fishermen that provide fishmeal factories with steady annual landings. Norway's fishing industry also supplies information, expertise, technical support, and equipment to fish farmers.

Sophisticated infrastructure: A very developed infrastructure system including ports, processing facilities, communication systems, and rapid transportation systems linking Norway to markets.

Educated population: A well educated, highly skilled labor force that has accumulated over 20 years of expertise in raising salmon.

Advanced technical support: A sophisticated support industry providing technical, bio-medical, environmental, marketing, and other services.

Leading scientific community: Norway's scientists are leaders in fish farming, genetics, feed, and treating fish diseases. Norwegian scientists have contributed to the pioneering work in salmon aquaculture. Norway's fish farmers benefit tremendously from the latest scientific breakthroughs in salmon aquaculture.

Knowledgeable bankers: A supportive banking system that understands the complexities of salmon farming and the long-term nature of raising fish. Many banks have suffered losses in recent years, but they rank among the world's most knowledgeable bankers when it comes to financing fish farms.

Skilled marketing specialists: Individuals and organizations that have identified and developed markets for premium-quality Norwegian products throughout the world.

A supportive government: The Government of Norway (GON) has supported the growth of fish farming and the marketing of Norwegian products. The GON is supportive of programs to maintain communities in the coastal ares of Norway, especially in the northern provinces.[2]

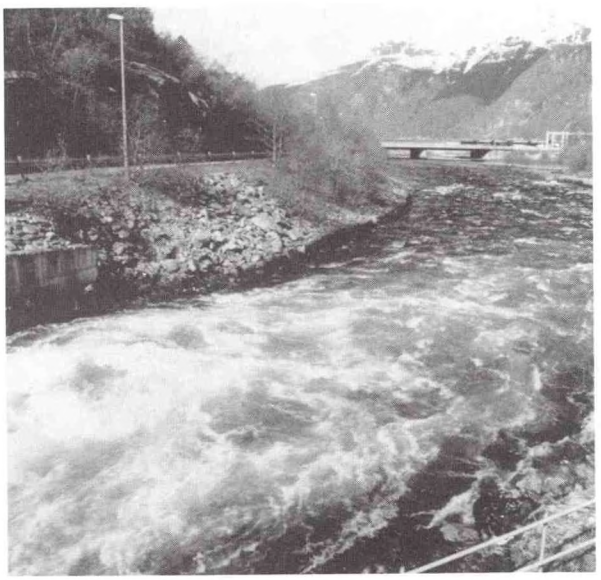

Figure 1--Snow fed rivers provide water for raising smolts.

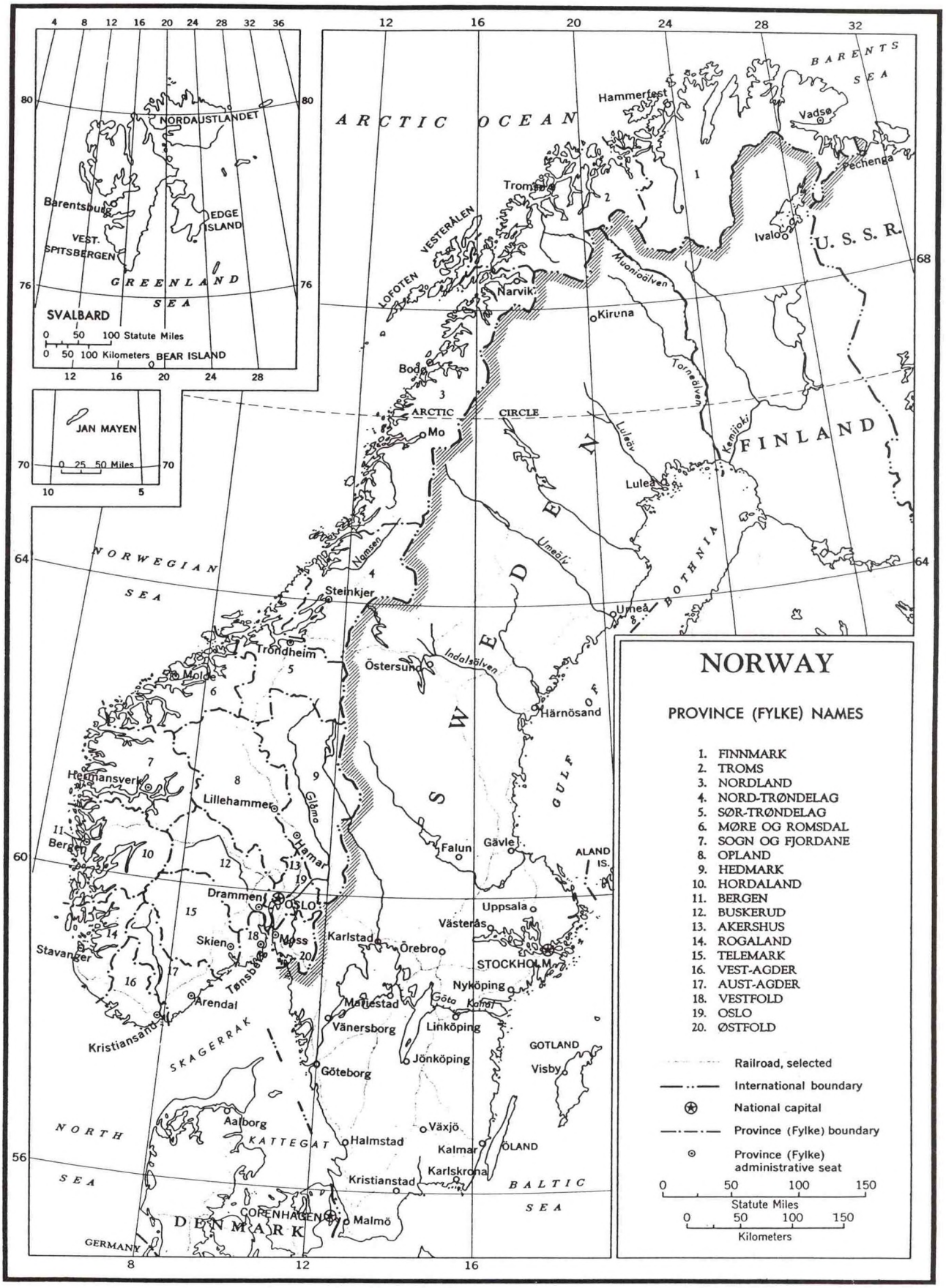

Figure 2.–Map of Norway.

B. Species

1. Biology[3]

Atlantic salmon (*Salmo salar*) are an "anadromous" species. Anadromous fish are born in freshwater but descend into the sea to feed and

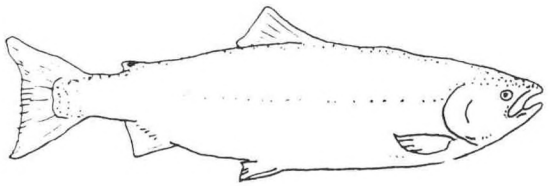

Figure 3.–The Atlantic salmon (Salmo salar).

mature. They return as adults to spawn in freshwater rivers and streams.[4] The salmon usually spawn in the fall. Females seek stream beds composed of gravel where they dig a nest to deposit eggs. They normally lay up to 1,800eggs per kilogram (kg) of body weight. The eggs are fertilized by a male and covered with gravel by the female. Some fish (kelts) remain in freshwater until the spring, when they migrate back to the sea. Unlike Pacific salmon, Atlantic salmon are able to spawn up to 6 times.[5] The eggs hatch in March or April. The young salmon fry (called "alevins")have a yolk sack which sustains them until about May or June when they begin to feed on small aquatic organisms. The fry remain in freshwater for about a year when they develop into "parr" with distinctive "thumbprints" on their sides. The parr remain in freshwater until they undergo the physical change, known as "smoltification", which prepares them for life in the ocean. When the process is complete, the smolts migrate to the sea where they will feed for 1 to 2 years. The fish usually return to spawn after 2 winters at sea (usually weighing over 4.5 kg)[6] to begin the cycle over again.

2. Culture

The process of raising salmon begins with broodstock. In Norway, these fish have been selected and raised to provide desirable traits.[7] Smolt producers strip eggs from the female, which are fertilized and transported to a hatchery. Following an incubation period of about 2 months, yolk-sac larvae emerge. The first 2 months are especially critical to survival and there is a high rate of mortality.[8] The fry start feeding about 1 month later. Special care must be taken to avoid the spread of disease during the hatchery phase and later during the smolt stage. High stocking densities common to fish farms stress fish, making them both more susceptible to and lowering their resistance to disease. Unless detected, a diseased fish can infect thousands of other fish -- a problem that has surfaced in Norway several times in the past 20 years.

Following "smoltification", the smolts (which weigh about 40 grams) are sold to salmon farmers. The smolts are transported to fish farms via live transport boats, large trucks, or are sometimes hoisted aloft by helicopters. They are placed into enclosed pens and fed special diets to promote rapid growth. Growth is generally the greatest during warm summer months when the fish are fed frequently. In winter, the fish are less active and are usually fed only twice a day. The young salmon are harvested when they reach "market-size" (usually between 2 to 5 kg), but before they reach sexual maturity. When the fish reaches sexual maturity, the quality of the flesh is reduced so sharply that it is not considered fit for consumption.[9] Most salmon reach sexual maturity about 28 months after smoltification. Thus, growers must harvest and sell their crop about 24 months after smolts are stocked in the pens.[10]

a. Diseases and parasites

Diseases: Norwegian salmon farmers have suffered many serious outbreaks of different diseases during the past 2 decades. Norwegian scientists pioneered much of today's research in salmon diseases, however, and thanks to their efforts, Norwegian salmon farms have developed measures to control the outbreak of diseases which, in previous years, would have resulted in massive mortality. These scientists not only developed medicines to combat disease outbreaks, but they helped establish strict Government guidelines to keep disease from spreading when outbreaks occur.

The "Hitra Disease" (a coldwater vibriosis caused by *Vibrio salmonocida*) broke out in 1985 and forced salmon farmers to destroy vast quantities of salmon and prematurely sell other fish in an attempt to control the disease.[11] By 1987, losses attributed to Hitra reached approximately $33 million.[12] Approximately 300 of Norway's 690 salmon farms were affected and losses reportedly reached 8,000 to 10,000 metric tons (t). This lesson graphically demonstrated the importance of careful farm management. Norwegian scientists were able to develop a highly effective vaccine which has brought this disease under control. Smolts that survived the disease retained their immunity and were sought for broodstock.

Norwegian salmon farmers also faced problems with furunculosis (caused by *Aeromonas salmonocida*) in the mid-1980's. Tough action to stop this disease resulted in some bankruptcies among salmon producers and again made it clear that sound management is necessary to prevent outbreaks of potentially very costly diseases. Norway's Veterinarian General is responsible for overseeing this management, and for health control of fish farms; it does this by closely monitoring farms and applying tough standards.

Sea lice: These small crustaceans (*Lepeophtheirus*) are a nuisance to salmon farmers. Sea lice attach themselves to salmon and feed on their flesh. The result is an unsightly blemish that damages the appearance of salmon. In heavy infestations, the fish attempt to rub themselves against nets or tanks, causing lesions which can become infected. Though sea lice also infect wild salmon, the high intensity of Norwegian salmon farming has led to infections much more severe than those found in the wild. In the past, Norwegian fish farmers used a variety of chemical treatments (including Nuvan, which has since been banned as a toxic pollutant) to control the lice. The problem, of course, was that the chemicals remained in the marine environment following applications, and repeated applications were needed during the growth process. Indeed, high concentrations of excess medications used in "dipping" salmon for sea lice infection were found in fish living around salmon pens. A further problem with "dipping"salmon is that the treatment caused the salmon severe stress. Salmon farmers could expect slowed growth and higher fish mortality in direct proportion to the frequency of dips -- not just because of the infection, but due to the treatment itself.

Norwegian scientists recently discovered a non-toxic method of fighting salmon lice by using a natural product extracted from ground chrysanthemum flowers.[13] The product, so safe that it is approved for use in food processing, is mixed with oil and poured on the surface of a fish pen to form a layer of medication. When the salmon jump, the extract covers their skin and kills the lice without harming the fish.[14] Norwegian salmon farms are also delousing their salmon stocks using "cleaner fish." These fish, which feed partially or exclusively on the small crustaceans, can apparently replace the costly,environmentally damaging, chemical delousing process. In industry trials using species of wrasse (such as *Ctenolabrus rupestris*), 1 wrasse to every 50 salmon decreased the need for chemical delousing by over 75 percent. This lowers the costs of delousing in time, chemicals, and fish loss (lost weight and mortality) by over 50 percent. Preliminary experiments with biological delousing began during 1988 and it is now being widely used throughout

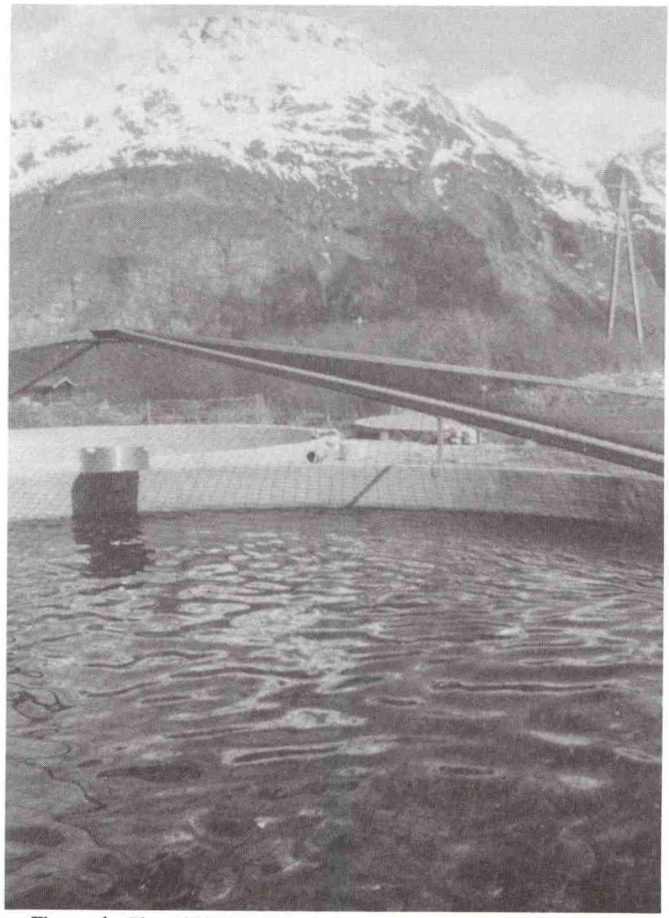

Figure 4.--The AKVAFORSK smolt research station at Sunndalsøra.

Norway.[15] A third such natural treatment for sea lice involves placing cut onions in salmon pens, which repels the small crustaceans. This very cost effective method is also receiving industry trials in Norway.

Scientists at the AKVAFORSK research station in Sunndalsøra report an even more interesting discovery. Their research shows that salmon lice generally congregate near the surface in shallow bays. By allowing penned salmon to live in deeper water -- below 10 meters -- the problem of sea lice virtually disappears.[16] This solution should result in a considerably reduced need for chemical sea lice treatment, but it involves expenditures to build deeper holding pens for the salmon.

b. Breeding

Breeding has played an important role in the Norwegian fish farming industry almost from the start. The first step towards establishing a breeding stock for culture was to obtain samples of Atlantic salmon from Norway's many different rivers and fjords. Research stations at Sunndalsøra and Averøy, carried out this and many other early projects.[17] Some 170 wild salmon "strains" were identified as discrete populations. After taking genetic material from these specimens, the research stations conducted research to determine if the farmed salmon would be sterile, or "triploid," by using chromosome manipulation.[18] If farmed salmon could be rendered sterile, they would not intermix with wild strains and change the genetic makeup of the wild populations. They would also remain marketable for longer periods of time. At the end of the project all of the triploid fish were destroyed. The Norwegian Fish Farmers Association stresses that *"no fish in Norwegian aquaculture meant for human consumption or commercial purposes has been genetically manipulated - engineered - tailored - tampered with, and we are going to make sure it stays that way."*[19]

The Agricultural Research Council of Norway took over the research stations at Ås, Averøy, and Sunndalsøra in 1984. From them, the Council created the Institute of Aquaculture Research (AKVAFORSK) as an independent research institute. One of AKVAFORSK's early success stories was breeding a salmon strain that grew at double the normal growth rate of wild salmon. AKVAFORSK was active in research on the differences between various strains' resistance to disease, age at sexual maturity, fat content, and feed utilization. AKVAFORSK also did research on preventive medicine and disease treatment. Researchers at Sunndalsøra also established an "egg bank" where the ova and sperm of different strains of Norwegian salmon are kept reposited in a frozen state.

AKVAFORSK has been especially involved in studying methods to enhance or control the color of salmon flesh through the use of astaxanthin and canthaxanthin.[20] Improvements to salmon remain an important part of the AKVAFORSK program in the 1990s, and efforts are underway to breed stress-resistant salmon, to reduce fat content to less than 8 percent, and to study respiration rates.[21]

The Norwegian Fish Farmers' Association (NFFA) and the Marketing Council for Farmed Fish (MCFF) are also actively involved in breeding research. In 1986, they established a new breeding station at Kyrksæterøra, about 100 km south of Trondheim. The facility has over 400 tanks for genetic studies. The station studies ways to reduce the proportion of early maturing salmon (grilse), to

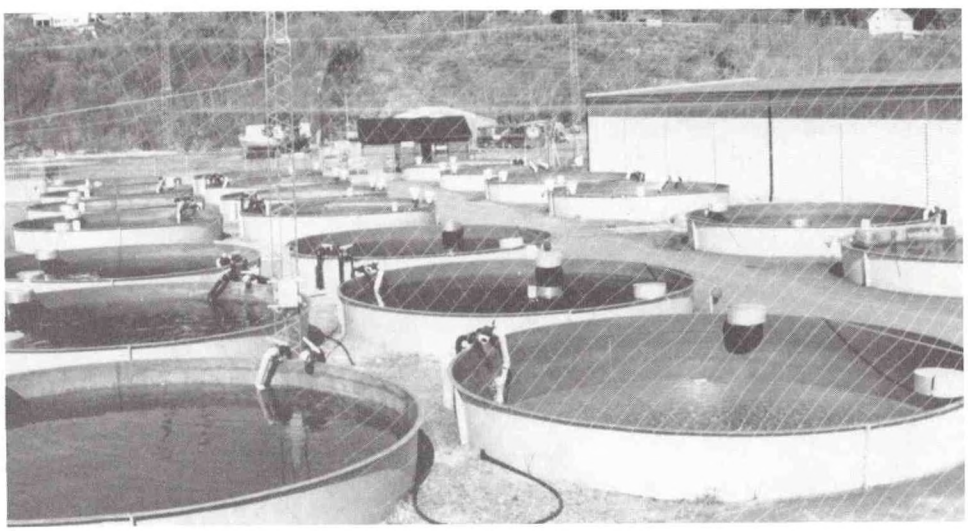

Figure 5.-- The NFFA's salmon facility at Kyrksæterøra.

obtain faster growth and better food conversion, to increase resistance to disease, and to obtain better market qualities for the fish through breeding programs.[22]

c. Environmental concerns

Salmon culture and the aquatic environment are interdependent. Salmon farming requires waters that are free of harmful chemicals, organic pollutants, and pathogenic microorganisms. However, salmon culture degrades its surroundings by introducing harsh or toxic chemicals into the environment, adding to the nutrient content of local waters (through fish excrement and uneaten feed), using medications to treat diseases, and threatening wild salmon stocks through the possibility of farmed salmon escaping and genetically compromising wild populations. Some of these concerns are no longer as pressing due to changes in sites and methods. For example, Norwegian salmon farmers now place a premium on water flow to insure an ever changing water supply through and around their pens. Early salmon farms were located in protected fjords or bays which have poor flushing capabilities, leading to an accumulation of fish feces and excess feed underneath the pens. When these waste products accumulate, they begin to break down. The decomposition process releases ammonia, hydrogen sulfide, and methane. Such waste byproducts are not only harmful to the salmon, but to other aquatic organisms, as well. The process also reduces oxygen levels and produces a fertile environment for the growth of bacteria and other microorganisms. Norwegian nutritionists are studying ways to optimize food consumption; better food consumption would reduce both food loss and waste byproducts.

Medication: Water pollution can reduce growth and disease resistance, which in turn leads to increased use of medication. Excess medication then becomes a pollutant. Because antibiotics and other chemicals cannot be prevented from entering the marine environment, medications not only affect the cultured salmon but the entire ecology around the site as well. Researchers at the Institute of Marine Research at Bergen have found high concentrations of medicine in wild fish found feeding near fish farms in western Norway and speculate that medicated fish feed is being eaten by wild fish. Blood tests revealed high concentrations of residues in fish caught within 400 meters of farms at least 2 weeks after medication of farmed fish had ceased. Norwegian marine scientists claim it is too early to draw any conclusions, but noted that preventing contamination of wild fish will receive a high priority.[23] Application of antibiotics per fish reached a high point in 1984 and doses have since been reduced, although total quantities reached a peak in 1987. The consumption of antibiotics in Norway's fish farming industry is shown in table 1.

Norwegian scientists have produced more effective vaccines, allowing the industry to reduce its overall chemical antibiotics usage even as the total number of farmed fish has increased dramatically. Norwegian scientists are concerned about the use of antibiotics in the marine environment and are emphasizing preventive medicine to avoid diseases. They are also conducting genetic trials to produce more disease-resistant smolts. This should also lower the quantity of antibiotics needed in salmon farming, and thus reduce the amount introduced into the marine environment.

Table 1.--Norway. Use of antibiotics by fish farms, quantities used per ton of fish versus total use of antibiotics, 1980-1988.

Year	Consumption	Total
	Kilogram/ Tons of fish	Kilogram
1980	0.46	3,660
1981	0.28	3,640
1982	0.43	6,650
1983	0.45	10,130
1984	0.70	17,770
1985	0.49	18,700
1986	0.36	18,030
1987	0.87	48,500
1988	0.40	32,000

Source: Norske fiskeoppdretteres forening, *The Norwegian fish farming industry in harmony with the environment,* Trondheim, Norway, 1990.

d. Salmon feed

Salmon feed in Norway generally consists of fishmeal (capelin, sand eel, or Norway pout), shrimp meal and other additives.[24] The high oil content of capelin, sand eel, and Norway pout makes them an excellent food that produces high growth rates. Norway's abundant deepwater, northern pink shrimp (*Pandalus borealis*) is another important component in the diet of farmed salmon. The hard shell (which is discarded after the meat is extracted) is used as a food additive to enhance or standardize the flesh color of salmon. The use of natural feeds allows Norwegian fish farmers to reduce or eliminate the use of artificial food coloring agents, permitting promotion stressing the fish as a "natural" seafood.[25]

Less than 10 years ago, salmon farmers needed

large quantities of feed to produce one kg of salmon. In 1983, for example, Norwegian fish farmers used 200,000 t of feed to produce about 17,300 t of salmon (a ratio of about 11.5 t of feed to 1 ton of fish).[26] In 1990, feed sales increased to 269,000 t, but resulted in significantly more fish being grown (145,000 t harvest, or 1.9 t of feed per ton of fish). Norwegian nutrition scientists have recently been able to produce 1 kg of salmon from only 1.1 to 1.2 kgs of dry feed, representing an excellent use of feed.[27] Fish farmers benefit from these developments through lower production costs.

II. SALMON HARVESTS

A. Hatcheries

Salmon eggs are produced by the Norwegian Agricultural Research Council's Research Station for Salmonids, the Directorate of Fisheries' Salmonid Aquaculture Station, and private broodstock farms. Genetically selected broodstock are used to produce fertile eggs which are hatched and nurtured until they are old enough to be sold to smolt farms.

B. Smolts

1. Early developments

Norway began experimenting with producing Atlantic salmon smolts in the 1960s. Development was fairly slow during the first formative years. In 1974, a decline in prices resulted in several smolt firms going into bankruptcy and smolt production remained limited. There were 87 smolt growers in 1980. The steady growth of salmon farming, however, created demand which continued to stimulate smolt production. Norway began to significantly expand its capacity to produce salmon eggs, fry, and smolts to meet the growing needs of the industry during the mid-1980s. In 1984, smolt growers produced 16 million salmon smolts which sold for about $1.75 apiece.[28] This did not meet the growing demand for smolts.

2. Breaking the bottleneck, 1985-86

Norway imported 5 million smolts to supplement domestic production during 1985. Unfortunately, some of the smolts imported from Scotland were infected with furunculosis. About 30 farms were infected and had to slaughter 2,900 t of fish.[29] The farms were then quarantined, resulting in several bankruptcies. This made reducing the flow of imported smolts and increasing domestic smolt harvests a government priority.[30] The GON reacted to this problem and to industry demands for more smolts by liberalizing domestic smolt production.[31] There were, for example, 152 salmon smolt producers operating in Norway reportedly producing 23.5 million smolts in 1985.[32] Yet, as a result of the government action, there were 333 smolt producers registered with the government by 1986, nearly twice the number registered in 1985.[33] Despite the problem of infected smolts, the GON approved the additional importation of 2.2 million smolts from Sweden, Iceland, and Finland to meet demand in northern Norway.[34] These actions set the stage for tremendous expansion of farm operations and ultimately contributed to the marketing problems that hit the industry in 1989-91.

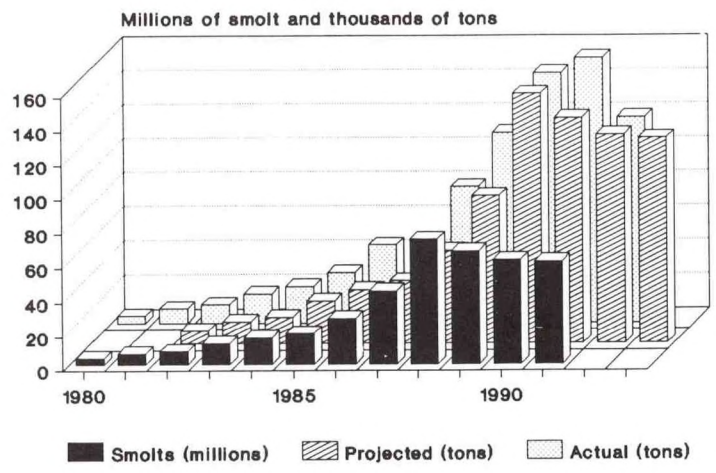

Figure 6.-- Salmon smolt production exceeded the ability of the industry to market the harvest profitably.

The Norwegian Fish Farmers Association (NFFA) began warning its members about the danger of overproduction in 1986.[35] The NFFA was in favor of limiting smolt supplies as a means of controlling salmon production. The NFFA stressed the importance of expanding markets in line with harvests.

3. Breakneck expansion, 1987-88

The Norwegian smolt industry was ready for another period of rapid growth in 1987. In a report to the National Assembly (Storting), The Ministry of Fisheries reported:

"So far, the farming of salmon and trout has been very profitable. In 1985, the smolt production sector showed a net return per man year (i.e., total income available for wages, minus total costs including calculated depreciation and interest on equity capital) of NOK 480,000 (about $80,000) and the return on total assets averaged 30 per cent. The comparable figures for the sector producing fish for human consumption were NOK 270,000 (about $45,000) and 18.5 per cent."[36]

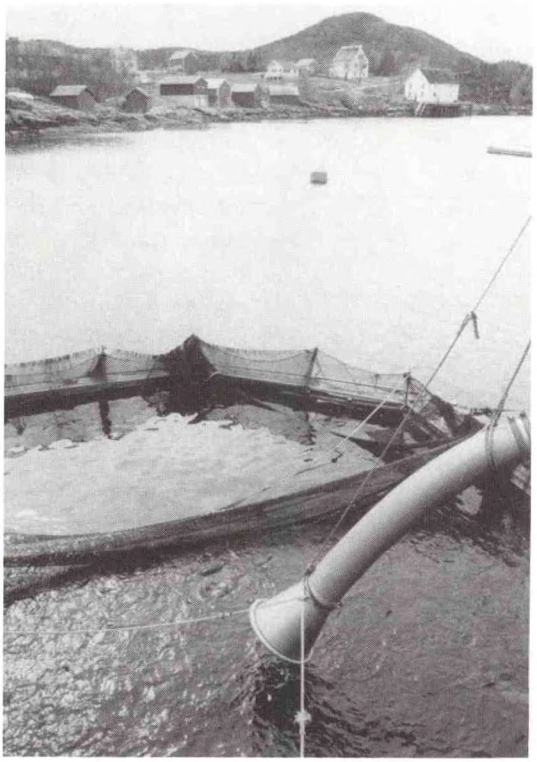

Figure 7.--Salmon grow-out pen. The pipe is used to transport salmon to processing facilities.

The Minister went on to report to the National Assembly that he was considering expanding the maximum production capacity of Norwegian salmon farms from 8,000 m^3 to 10,000 m^3 or 12,000 m^3 and that additional licenses would (or could) be issued in the next 1-2 years. This news convinced many Norwegian fish farmers to expand their operations. Although salmon smolts were selling for $3.13 apiece (20 kroner each),[37] salmon farmers went on a buying spree that pushed smolt production to 40 million in 1987. The demand for smolts was so great that another "bottleneck" appeared. Kari Bjørbæk and Erik Hempel, speaking at the World Aquaculture Society meeting in Hawaii in January 1988, reported that "in late 1987 we did experience a shortage of smolts. This was because farmers were setting out record amounts and hatcheries were not working at full capacity."[38]

Norway reportedly had 659 smolt producers with a capacity of about 205 million smolts in 1988. The producers supplied smolts to 747 salmon grow-out farms, with a total volume of over 5 million m^3 and an estimated production capacity of 100,000-110,000 t per year. Norway's domestic requirement for smolts was thought to be about 60 million smolts annually, which would yield about 120,000 t of market-sized salmon.[39] It now appears that Norwegian smolt producers increased production from 43 million in 1987 to 73 million smolts in 1988.[40] According to normal salmon growth patterns, 43 million smolts would mature into approximately 86,000 tons of salmon 24 months after smoltification (i.e., 1989). Likewise, 73 million smolts would yield 145,990 t in 1990.[41] Actual salmon harvests were reasonably close to these predictions: salmon farmers harvested 111,000 t in 1989 and 158,000 t in 1990. In retrospect, the production of smolts in 1987 and 1988 helped set the stage for the flood of salmon that would overwhelm the market in 1989 and the early 1990s.

4. Reduction in production, 1989

The 43 million smolts placed into fish ponds in 1987 reached market-size during 1989. However, the supply of fish was more than Norway's skilled exporters could channel through traditional markets.[42] Month after month, salmon harvests grew, swamping export markets around the world and depressing salmon prices. Norway's smolt producers failed to anticipate the crisis and many were caught with large inventories as salmon growers reduced their purchases or cancelled their orders. This forced many smolt producers to sell their smolts at "bargain basement" prices. Some salmon growers took advantage of the lower smolt prices by **increasing** their purchases, and thus prolonging the crisis.[43] By 1989, smolt sales to fish growers amounted to 66 million smolts (the equivalent of 132,000 t of market-sized fish in 1991).

5. Limiting smolt production, 1990-92

The NFFA announced plans to destroy 15 to 20 million smolts in an effort to limit production to 65-70 million smolts (the equivalent of 130,000-140,000 t

of mature salmon) during 1991.[44] Purchasing and destroying smolts was the most cost-effective short-term means of dealing with the problem. The destroyed smolts can be used for fishmeal and oil, thus removing them completely from the salmon market. The alternatives are to continue feeding salmon and flooding the market, harvesting juvenile salmon before they reach market size, or freezing mature salmon. Each option is costly (especially if stocks cannot be sold at the full cost of production) and can disrupt existing markets for salmon. Freezing salmon is not only expensive, it is also only a temporary solution. Salmon can remain frozen for only a limited amount of time before the fatty tissues begin to turn rancid.

GON officials have since reported that 15 million smolts were destroyed in 1991, leaving 60 million smolts available for sale to salmon farmers[45]. Thus, Norway has taken steps to limit the 1992 harvest to about 120,000 t.[46]

C. Grow-out

1. Pioneer years, 1960-1980

Pioneers such as Thor Mowinckel first began farming salmon and trout in Norway during the 1960s. During the first decade, harvests were low as farmers struggled to learn how to raise salmon. By 1970, there were only five fish farms producing salmon in Norway. Harvests exceeded 100 t for the first time in 1972. Licensing of fish farms started with the Fish Farming Act of 1973. Under that Act, most investors seeking licenses were granted permission to start fish farming. In that year, one farm went bankrupt and the number of farms decreased to 4 facilities. Between 1974 and 1977, however, the number increased from 13 to 84 farms. In 1977, the GON began regulating the number of new licenses issued and began imposing restrictions on the size of salmon farms. In 1978, there were 116 farms and total salmon harvests reached 3,500 tons. The Norwegian Fish Farmers Sales Organization (FOS) was created on July 28, 1978, and given the sole right to sell farmed fish to approved buyers.[47] The FOS was tasked to (1) achieve good and stable prices for farmed fish products, (2) negotiate minimum prices for farmed fish, (3) influence harvests in relation to market potential, and (4) promote and market Norwegian farmed fishery products at home and abroad.[48] The FOS was financed through a fee of 3 percent, 1.5 percent paid by each fish farmer and 1.5 percent by the salmon buyer.[49]

2. Formative years, 1980-1985

By 1980, there were 173 farms and harvests reached 4,300 tons. In 1981, with 215 farms in operation, the GON established a formal act making it illegal to establish new (or to expand old) fish farms without permission. In 1982, the GON issued 50 new licenses and followed this by issuing 80 new licenses in 1983.[50] Thereafter, a gap appeared between the number of licenses issued and the number of farms actually in operation.[51] The GON also passed a law restricting the size of salmon farms to 8,000 cubic meters.[52] The move was designed to encourage local residents to raise salmon. This was in accordance with the Regional Development Policy to foster small-scale industries in the coastal communities of Norway, especially in the Northern provinces. A 8,000 m^3 farm was considered "small" and was designed to operate efficiently as a small-scale (or family-run) enterprise. This was part of the GON policy to promote employment in isolated communities.

By 1983, there were approximately 301 salmon farms in operation producing an average of about 30 to 40 t of fish annually. Norwegian harvests reached 17,298 tons.[53] The year was not, however, without significant problems. Farms in Trøndelag were infected with furunculosis which forced 30 salmon farmers to destroy their entire stock of salmon.[54] This was the first serious outbreak of disease in Norway and it would be followed by other outbreaks in coming years. In 1983, the leader of Norway's salmon farming business was the MOWI firm, located near Bergen, which reportedly harvested 500 t of farmed salmon annually.[55]

Farmed salmon became Norway's second most valuable fishery, exceeded only by cod in terms of value, during 1984.[56] The salmon harvest was 29,500 t worth about $100 million, compared with Norway's cod catch which was valued at about $108 million.[57] In 1984, there were approximately 354 salmon farming operations in Norway (out of 475 licenses issued[58]) with production capacity of 40,000-50,000 t of salmon per year. Norwegian farmers exported $120 million worth of salmon in 1984. The average salmon farm ranged between 10 m^3 and 1,200 m^3 and employed 2,000 people directly and another 2,000 in related activities.[59] The size of the average salmon farm, thus, was still below the 8,000 m^3 farm size authorized by law. The position of the GON in 1984 was to allow increased harvests with only minimal intervention. The Government approved new sites for fish farms but continued to restrict farm size.[60]

Applicants for new salmon farming licenses were required only to demonstrate sufficient capital to meet 25 percent of the start-up costs, the technical skill to operate a salmon farm, and a suitable site.[61] The GON policy was aimed at maximizing the number of small fish farm operations in order to provide employment opportunities in remote areas. Unfortunately, the policy made it difficult for Norwegian producers to achieve economies of scale in salmon production. It also led to higher production intensity (the number of salmon per pen); this increased the environmental impact of salmon culture and the risk of disease, as well as decreased the size, weight, and muscle tone of the average Norwegian salmon produced. Another important drawback to the GON policy was that it forced some of the brightest and most successful Norwegian fish farmers to set up fish farms in foreign countries -- farms that would compete with domestic producers in the future.[62]

3. Expansion of the industry, 1985-87

The GON again amended its regulations on fish farming in 1985, making it more difficult to obtain licenses and placing further restrictions on fish farmers interested in building large-scale farms. The regulations continued the GON policy of favoring small enterprises that would provide employment opportunities in remote areas, particularly in the northern provinces of Norway. Improved technology meant that an 8,000 m^3 cage could safely hold 150 to 200 t of salmon, or 3 times more salmon than could be raised under similar conditions in 1984. Despite the new regulations, demand for licenses was so strong that there were 2,500 applicants for the 150 licenses awarded during 1985.[63] Trond Bjørndal, in *The Norwegian Aquaculture Industry*, explained that obtaining a salmon license was seen as highly valuable: "*The high profits...earned in fish farming have meant that ownership of a license has been sufficient to obtain financing.*"[64]

The GON had issued 728 salmon licenses in 1986, but only 636 farms were in operation. The harvest of farmed salmon was 45,675 tons. This was about 8,000t more than had been planned for the year: the rapid spread of the "Hitra" disease (a coldwater vibriosis caused by *Vibrio salmonocida*) forced farmers to harvest 8,000 t of smaller-sized salmon before they could be infected. Thus, more salmon was sent to market than was planned; some of the salmon would have been harvested in 1987, if the threat of disease had not forced farmers to harvest their fish prematurely.

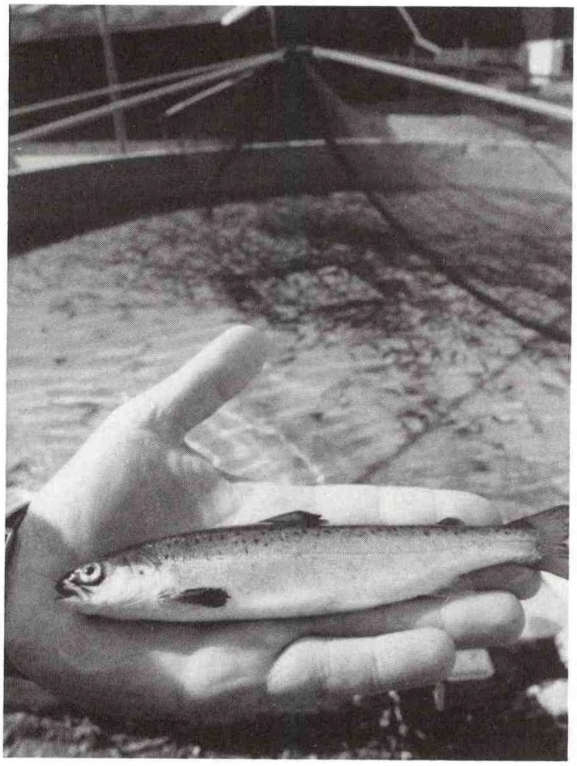

Figure 8.--A smolt ready for sale to salmon farmers.

In 1987, Norwegian salmon farmers harvested 47,420 t -- only 2,000 t more than was harvested in 1986. However, these fish helped Norway generate record export returns. In 1986, for example, the harvest of 46,000 t of salmon produced exports worth $233 million. One year later, in 1987, the salmon harvest of 47,400 t yielded exports worth $314 million, a difference of nearly $81 million! This convinced many investors that salmon farming could be very profitable and helped set the stage for the "gold rush" approach to salmon farming that characterized business in the following year. In 1987, a total of 750 licenses were granted for the production of salmon (and trout). The aquaculture industry provided employment for 10,000 full-time workers (5,000 in aquaculture and 5,000 in support fields).[65]

4. The salmon "gold rush", 1988

The year 1988 was significant to Norway's salmon farming industry, because the Government bowed to heavy industry pressure and permitted fish farmers to increase the size of individual farms from 8,000 m^3 to 12,000 cubic meters. This increased the cubic growing capacity for farmed salmon from about 5

million m^3 to 8 million m^3 and allowed Norwegian salmon farmers to increase their output by 50 percent. The Government took this step because of mounting political demands by Norwegian fish farmers and investors hoping to profit from the spectacular success of the industry. By liberalizing controls, the GON set the stage for overproduction. Many of Norway's 728 fish farmers immediately rushed out and purchased additional smolts and grow-out pens to stock their new facilities. Developments in controlling diseases and increasing the effectiveness of feedstuffs allowed even greater stocking densities and made it possible to use existing growing facilities more effectively. Combined with the additional legal growing space, these advances produced a production boom. In 1988, Norway's harvests of farmed salmon amounted to nearly 78,700 tons; 2 years later harvests doubled to 146,000 tons. The production attained in 1990 suggests that 73 million smolts were placed into grow-out pens in 1988, and the 50-percent increase in production volume for each farm allowed the farmers to double their output. In retrospect, it is clear that the legislation to increase farm pen sizes from 8,000 m^3 to 12,000 m^3 helped stimulate the industry into producing more salmon than the market could absorb profitably. Curiously, as this important step was being taken, two of Norway's best known salmon authorities were unable to find any studies that could predict world market for Norway's future salmon harvests. Kari Bjørbæk and Erik Hempel, writing in *Fish Farming International* in March 1988 stated:

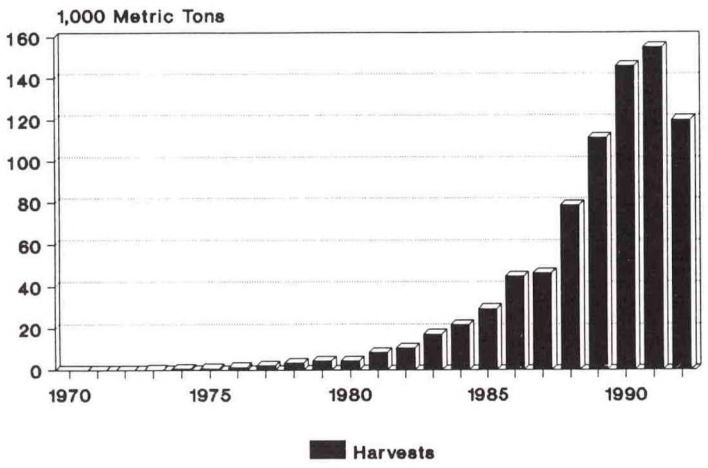

Figure 9.--Norway. Production of farmed salmon, 1971-91 with projections for 1992.

"When preparing this paper, we searched high and low for some authoritative figures on the future market demand for farmed salmon. We did not find much. Most people were telling only about production forecasts. Perhaps this is what most people in the industry believe: that in the foreseeable future demand is limited only by supply."[66]

It is noteworthy that both of these authorities were employed in the Royal Norwegian Ministry of Fisheries at that time[67] and that they were in an ideal position to obtain information about future markets if it had been available. In retrospect, it now appears that few were concerned about future markets and that investors were so excited about expanding production that they gave little thought to market demand. Ultimately, the warnings issued by Kari Bjørbæk and Erik Hempel in 1988 were lost in the pressure of day-to-day business. The failure of the fish farmers to focus on market expansion was also partially the result of the industry's market structure: the FOS was responsible for marketing. Norwegian farmers received fixed prices from the FOS, and growers were only responsible for production.

5. Overproduction, 1989

In 1989, the Norwegian farmed salmon harvest was 114,900 t and 95 percent of this harvest was exported, earning over $500 million in revenues. This was nearly 33 percent more than, or 31,200 t above, the 83,700 t produced in 1988 and contributed to a 17 percent decline in world salmon prices compared with the previous year.[68] A U.S. Embassy report on Norwegian aquaculture[69] for 1989 acknowledged the tremendous growth in Norwegian salmon farming, but noted that problems had surfaced during the past year:

"The anticipated rise in capacity increases the danger of market oversupply. Already, it is noted, salmon prices fell 10 percent during 1988. Should prices fall further in 1989, a number of firms which had bet on expansion and increased revenues may face liquidity problems."[70]

The Embassy reported that banks were becoming reluctant to loan money to finance the 1990 crop of salmon, in part because of growing bankruptcies in the industry. Some of these bankruptcies were precipitated by increasingly lower prices for farmed Atlantic salmon on world markets. For example, in April 1989, the Dutch retail market price for Norwegian salmon dropped by 50 percent, to $18/kilogram[71] and salmon farmers in Scotland and Ireland began voicing their belief that Norwegian salmon farmers were selling their product below the cost of production. The Scottish and Irish complaints succeeded in persuading the EC to investigate alleged Norwegian "dumping" of salmon on the EC market.[72] The problems facing Norwegian producers, thus, were spreading beyond the borders of Norway and would soon stimulate an international crisis. In mid-summer, Saga Seafood of Bergen filed for bankruptcy. The company, which was headed by Norwegian salmon farming pioneer Thor Mowinckel, was the first major casualty of the decline in world salmon prices. Ironically, the flood of Norwegian salmon entering the market and the very efficiency and capacity of the Norwegian industry were rendering Norwegian salmon farming unprofitable.[73] In July 1989, Odd Berg, the FOS Director of Marketing, predicted that Norwegian salmon farmers would produce 120,000 t of salmon in 1989, 140,000 t in 1990, and 150,000 t in 1991. He warned that if harvests exceeded 120,000 t in 1989, then some salmon exports would have to be delayed or extended until early 1990. This was another sign that the surge in production was beginning to worry Norwegian salmon exporters by mid-1989.[74] In August 1989, Norwegian Fisheries Minister Bjarne Eidem temporarily suspended issuing new licenses to salmon farmers. Eidem stated that there was a danger that the industry had expanded too rapidly and that fish farmers were concentrating on quantity rather than quality.[75] Other officials, however, believed that the market for Norwegian salmon was expanding faster than Norway's harvests, and that the market would be able to absorb the large increase in harvests forecast for 1989 and 1990. Again, these statements indicate a growing awareness of the dangers of overproduction, but the continued perception of many growers that the market could absorb Norway's huge production prevailed over the warnings.

By the autumn of 1989, the industry began feeling the price collapse and increasing numbers of farms went bankrupt.[76] The FOS released a projection that 1990's harvest of farmed salmon would decline to 110,000 t instead of the 150,000 t confidently projected only a few months earlier.[77] The NFFA claimed that many farmers planned to delay harvests or limit their salmon operations. The Association also reported that 10 million fewer smolts were stocked during 1989, compared with 1988.[78] The NFFA proved roughly accurate, as actual harvests in 1989 amounted to 115,000 t, close to the figures announced by the NFFA, but were still 31,000 t more than was harvested in 1988.[79] The Association underestimated the number of smolts growing throughout Norway that were rapidly reaching market size. By November 1989, the FOS reported that Norwegian salmon farmers were facing losses approaching $29 million because of falling prices and sales below expectations. Norwegian salmon farmers, for the first time, conceded that quotas might be needed to limit the growth of exports.[80]

6. Major disruptions, 1990-91

The situation deteriorated to such an extent that on January 4, 1990, the FOS announced plans to take 20,000-40,000 t of salmon off the market by buying and freezing it.[81] The FOS borrowed $200 million from private banks to finance the freezing plan, and imposed a levy of $0.75/kg on all exports of fresh salmon, in order to pay off the loan. Additionally, FOS called upon Norwegian salmon farmers to reduce or delay harvests by decreasing feeding schedules.[82] FOS Director Odd Ustad stated that the combination of the freezing plan and the tax on exports of fresh salmon would keep prices to producers at about $6.30/kilogram. Funds raised by this "tax" would help repay the $200 million loan used to finance the freezing program.[83] The plan also called for pen production limits of 25 kg per cubic meter and limits on the number of smolts that farmers could purchase.[84] The FOS marketing strategy had a positive short-term impact. Fresh salmon export prices increased from $4.83/kg in December 1989 to $5.20/kg in January 1990 and eventually increased to $6.49/kg by December 1990. This action, intended to protect fresh salmon prices, had an important indirect result: it increased Norway's involvement in the frozen salmon market, previously an area of only limited interest.

The FOS, and salmon farmers around the world, anticipated that Norway's actions would siphon off excess fresh salmon and allow prices to increase.[85] Unfortunately, the marketing strategy failed to gauge consumer demand for bargain-priced luxury salmon and consumers continued to demand this luxury seafood. Thus, instead of decreased sales in 1990, exports reached a record 111,300 t in 1990, compared with 99,000 t in 1989. This, unfortunately, masked

the underlying problem of overproduction in the industry. Despite strong demand and record exports, the problem of overproduction remained and nearly 10 percent of the industry went into bankruptcy.[86]

In 1991, the Norwegian Ministry of Industry proposed ending restrictions on entry, ownership, and control of fish farming in Norway. A draft regulation would have abolished requirements that local residents need to own a controlling share in fish farms and that individuals and corporations could not hold controlling interests in more than one fish farm. Industry observers indicated that liberalizing the industry would likely result in larger, more market-oriented fish farms. At the same time, legislation was being proposed that would strengthen the quality control and other aspects of fish farming operations to prevent the spread of disease in Norway's salmon farming industry.[87]

Less than six months after the NFFA celebrated its twentieth anniversary in September 1991, it reported that it was close to bankruptcy. NFFA income declined because of low salmon prices and reduced membership fees caused by the many bankruptcies in the aquaculture industry. Its finances were further strained by the financial demands of Norway's large salmon freezing campaign, legal costs stemming from salmon dumping charges, and poor investments. The NFFA reportedly was $300,000 in debt to the FOS. NFFA announced a plan to reduce staff, abandon many planned projects, and implement other severe cost cutting measures as a means of remaining operational.[88]

The NFFA was not the only salmon organization in serious financial trouble. The FOS, the organization responsible for marketing over 70 percent of Norway's farmed salmon for over 13 years, announced that it was bankrupt on November 13, 1991. FOS reported debts reaching $312 million.[89] The organization had gone heavily into debt as a result of its program to freeze more than 37,540 t of farmed Atlantic salmon in an effort to stabilize world salmon markets.[90] FOS's bankruptcy casts doubt on the health of the entire Norwegian salmon aquaculture industry. Many salmon growers faced bankruptcy as a result of FOS' demise. In some regions, almost all export sales were channelled through FOS, and those salmon growers were eventually to receive only 49.5 percent of what FOS owed them.[91]

The FOS announcement brought the industry crisis to a head. It was finally clear to the industry, and to the world, that the FOS salmon marketing program had failed massively and that many Norwegian farmers were close to bankruptcy. To insure that farmers received at least half of what FOS owed them, the Norwegian government agreed to finance, with credits of up to $62 million, the creation of a new export sales company to purchase and market Norway's 37,540 ton "mountain" of frozen salmon left by the freezing scheme.[92] The GON also announced that it would contribute both technical and financial support to fish farmers through the Regional District Fund (Distriktenes Utbyggingsfond).[93] The GON reportedly did not expect repayment of the loan unless the frozen salmon sold for more than $4.33 per kilogram. The GON also indicated that the frozen salmon must be sold in non-traditional markets (such as Eastern Europe) to avoid disrupting traditional markets. A consortium of Norwegian banks[94] promised to loan the new export company up to $43 million. The funds were to repay fish farmers still owed by the FOS following its bankruptcy. In addition, the banks agreed to extend $8.5 million in credits to meet regional needs and stated they would consider making loans to individual fish farmers to help them cover their remaining balances with the FOS. Despite the quick action, many press observers anticipated a chain of bankruptcies in the Norwegian salmon industry, which generated approximately $1 billion in export earnings and employed nearly 15,000 people in 1990.[95]

T. Skretting A/S, a Norwegian subsidiary of British Petroleum's Nutrition Group, on November 14, 1991, announced that the GON might authorize it to market the frozen salmon, with the understanding that the stock would not be sold in EC markets. The NFFA reported that it had found the funds to operate into mid-December 1991. Left on shaky ground by the collapse of the Norwegian FOS, the NFFA may still face long term financial difficulties. Observers expect further problems in the Norwegian aquaculture industry, and it may only recover slowly from the disastrous FOS bankruptcy.[96] The Norwegian Seafood Export Council, established during July 1991, took over the activities of the Marketing Council for Norwegian Salmon (MCNS). MCNS was in danger of collapse following the bankruptcy of its parent organization, the FOS. The new Council will continue to use the "Norwegian Salmon" registered trademark in its marketing efforts. The Council stressed that, though marketing farmed salmon would be the main focus, the Council will promote all Norwegian fishery products.[97]

7. Outlook for 1992

Harvests of farmed salmon are projected to reach about 120,000 t in 1992.[98] The situation for the salmon farming industry remains precarious. The financial stability of the industry is still uncertain and many firms may go bankrupt before the industry recovers. The industry is still faced with the daily need to feed hungry salmon and to finance other costs necessary for maintaining operations. Banks are unwilling to grant credit and creditors are demanding payment. Foreign clients want fish, but not at premium prices, and foreign competitors are aggressively moving into Norway's markets. The industry also has used up the financial reserves needed to recover lost markets or to expand into new areas. Finally, few members of the industry have the financial resources to develop new product lines and to successfully introduce them to consumers.

III. EXPORTS AND MARKETS, 1990-91

The problem associated with massive harvests was not completely unexpected. The Ministry of Fisheries warned the National Assembly of the potential problem in 1987:

"Although up to now the fish farming industry has been very largely production-oriented, the industry has successfully avoided serious sales problems. ***In the future, it must be recognized that it will become increasingly more important to direct production more systematically towards the products and quantities that it is possible to sell. This makes it necessary to strengthen integration of the production and marketing sectors."*** *{emphasis added}*

"The challenge lies in selling 100,000 tons of salmon on a market where offers from other countries are also increasing." *{emphasis added}*[99]

It is clear that the Government of Norway was aware of the need to expand markets at a rate exceeding domestic *and foreign* harvests and that it was warning the nation of this problem as early as 1987. Unfortunately, this warning went largely unheeded in the face of expanding consumer demand from around the world as more and more people purchased this luxury seafood product at ever lower prices.

A. Exports

Norwegian exports of farmed salmon reached 132,000 t worth about $800 million in 1991 compared with 111,000 t worth $772 million in 1990. Farmed salmon is the most important commodity in Norway's fishery exports, comprising over 13 percent of total fish exports by quantity. Despite widespread problems in the Norwegian farmed salmon industry, Norwegian salmon exports have continued to surge. During the five months of 1992, exports of farmed Norwegian salmon were 48,849 t versus 51,263 t during the same 5 months of 1991. The 1991 exports included 32,300 t of fresh salmon. The average 1992 export price, however, declined slightly from previous years.[100] Many Norwegian salmon farmers in early 1992 were selling their products at low prices simply to remain in operation. Few banks were lending money to keep fish farms afloat. These booming sales were a source of concern within the Royal Ministry of Fisheries, which worried about possible EC retaliation against Norwegian salmon.[101] Sales were so brisk that some observers are worried that there may not be enough fresh salmon available to meet the December rush, when prices are expected to be high.[102]

1. Commodities

a. Fresh

Approximately three-fourths of Norway's total salmon exports consist of fresh or chilled salmon. Indeed, fresh farmed salmon exports account for one-third of Norway's total fisheries exports.[103] Despite efforts to diversify into frozen and value-added products, fresh salmon remains one of Norway's most important export commodities.[104] When prices for fresh salmon plummeted during 1990, Norwegian exporters and salmon growers could not recover costs. Because of the importance of fresh salmon exports to the overall Norwegian fisheries industry, this caused severe dislocations throughout the economy.

b. Frozen

Frozen salmon began increasing in importance in the late 1980s.[105]It grew even more important in 1990 when the FOS program to freeze excess harvests began. The FOS plan opened up a new commodity which proved to be well received on world markets. Exports of frozen salmon (including frozen fillets) nearly tripled from 14,000 t in 1989 to 39,800 t in

1990. Sales declined slightly during 1991, when exports were about 35,000 tons. Analysts report that the decision by the EC not to impose an 11.4 percent penalty on imported salmon helped export sales.[106] It is likely that Norwegian exporters will continue to market their product in frozen form in the future, provided the market for fresh salmon recovers sufficiently. Frozen salmon are particularly attractive to seafood smokers and processors that can afford to store their product until it is needed. Fresh product, by contrast, must be used quickly. Thus there is a market for frozen product that can be met by Norwegian exporters. Finally, the willingness of consumers to buy some quantities of frozen product will serve as a "safety valve" for future harvests of fresh product. It should be stressed that new quality standards were enacted as part of the freezing program. Meticulous attention was paid to quality, from the moment the salmon was harvested until it was frozen. The program including careful handling, glazing, and individual packing in plastic bags for each fish. The salmon was quick frozen to very cold temperatures (-33 degrees C) to preserve the product. This produced a very high quality product that helped establish a market for the "new" salmon product.[107]

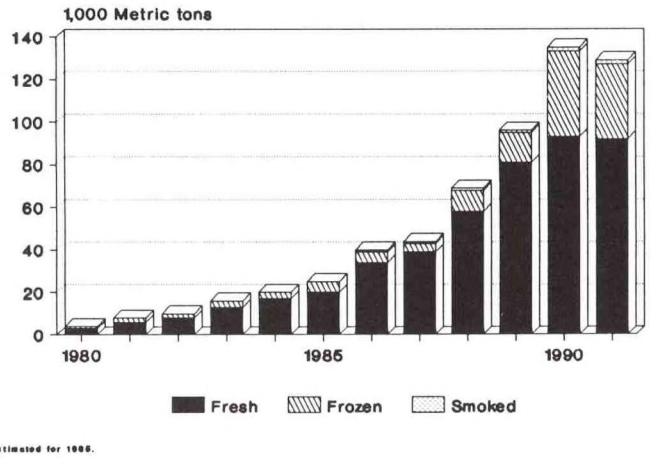

Figure 10.--Norway. Exports of farmed salmon, by product form, 1980-1991.

The development of new markets for frozen product, however, did not solve Norway's immediate problem with its "mountain" of 37,540 t of frozen salmon. This mountain was an important contributing factor leading up to the bankruptcy of the FOS in November 1991. Norwegian efforts to reduce this mountain began to produce results in March 1992. By May 1992, the "mountain" of frozen salmon had been mostly sold to non-traditional markets.[108] About 6,000 to 7,000 t, however, was held in reserve for sale during the holidays.[109] All of the mountain was sold by Aquastar as a result of pre-existing orders (8,500 t to the EC and 6,000 t to Japan) or was sold to non-traditional markets in Poland, Hungary, Israel, India, and also some Middle Eastern and African nations, according to specifications established by the GON.[110] Very little of this salmon reportedly was sold in Norway for domestic consumption.

c. Other forms

Exports of smoked products declined slightly from 1,900 t to 1,800 t in 1990. The United States (381 t) was a key market followed by Sweden (288 t), Germany (174 t), Italy (140 t), Spain (109 t), and Switzerland (107 t). In addition to smoked salmon, the Norwegian industry is attempting to develop a variety of new products for export markets. One new product was a small 100-gram tin of canned salmon pâté which appeared in 1992.

2. Countries

The EC is the principal market for Norwegian farmed salmon. Thanks largely to higher sales to Spain and Italy, 1991 exports were about 104,000 t worth $550 million). Information about Norway's salmon exports are available in the appendix section.

a. Denmark

Norway exported a record 32,800 t of fresh and frozen salmon to Denmark in 1991, making Denmark the nation's most important client.[111] Very little salmon, however, is actually consumed in Denmark. Danish companies process the raw product into valued-added, finished seafood products which are exported, mainly into the European Community.[112] Denmark imported almost 17 percent of Norway's total 1990 salmon harvest. This arrangement also provides a strong boost to the Danish seafood processing industry.[113] It should be noted that some of this salmon represented excess stocks of frozen salmon that simply could not be stored in Norway because most cold storage facilities were already filled with the mountain of frozen salmon. Thus some salmon was shipped to Denmark, Germany and Sweden for storage. When these salmon left the Norwegian frontier, however, they were listed as exports. Some of the salmon may have ultimately

been re-exported to other clients.[114]

U.S. industry representatives have complained that fresh Norwegian salmon was being sold to Denmark and then re-exported to the United States: approximately 120 t of fresh Atlantic salmon was shipped into the United States by Danish exporters between April and August 1991, before shipments were halted.[115] Since Denmark does not raise farmed Atlantic salmon, it is likely that this fresh salmon was Norwegian-origin product.

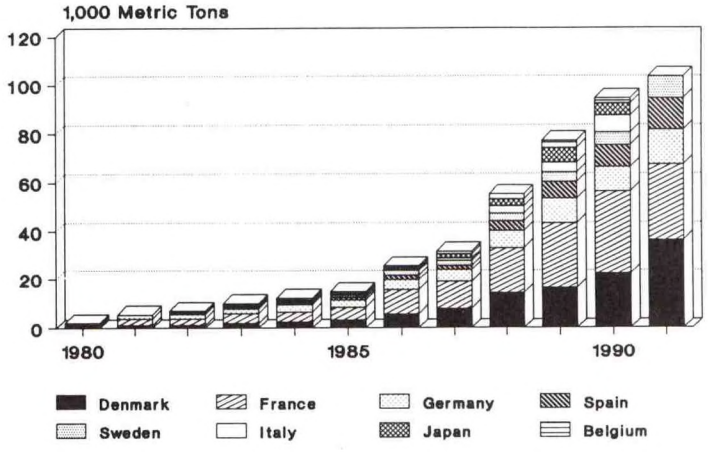

Figure 11.-Norwegian exports of farmed salmon to its top markets, 1980-1991.

It appears that Denmark has become Norway's most important outlet for unprocessed product used to produce smoked salmon and this trend is likely to continue in 1992. Danish importers reportedly pay higher prices for Norwegian salmon than for salmon from any other country. This fact, if accurate, counters claims that Norway is "dumping" salmon in European markets. Their knowledge of, and proximity to, European customers allows the Danes to make a profit in handling sales of Norwegian salmon in Europe.[116]

b. France

France has traditionally been Norway's best customer. The French have a profound love of salmon, especially smoked salmon. In 1991, however, France was replaced by Denmark. Norwegian sales of fresh and frozen salmon increased from 2,700 t in 1981 to a high of 33,700 t in 1990 before declining to 29,800 t in 1991. It is not clear why the French market declined in 1991. It is possible that other nations have begun to target France and that may account for some of this decline. The Norwegians place considerable emphasis on promoting the sale of their salmon products at the SIAL World Food Show which is held in Paris every other year. It is likely that efforts to rebuild the French market will be an important part of future export efforts.

c. Germany (FRG):

Germany is another very important market for Norwegian salmon, accounting for about 10 percent of total fresh and frozen exports in 1991. Exports of fresh and frozen salmon to the Federal Republic have gone from 1,600 t in 1981 to 13,200 t in 1991, while smoked salmon exports amounted to 174 tons. The Norwegians make a significant effort to promote their farmed Atlantic salmon at the ANUGA World Food Shows held in Cologne every other year. Some of Norway's "mountain of frozen salmon" was shipped to the FRG for storage; this product was shown as a Norwegian export to the FRG, even though some product may have been sold to other countries by the Norwegians.[117]

d. Italy

Exports of fresh Norwegian salmon to Italy have expanded quickly during the last few years and Italy is now Norway's 6th largest customer. Norwegian exporters first shipped product to Italy in 1983 (only 80 t) and exports remained less than 1,000 t through 1988. In 1990, exports approached 4,000 t and increased 6,400 t in 1991. The Italian and Spanish markets share many similarities, and it is likely that Norwegian farmed salmon will gain popularity in the Spanish market in the next few years.

e. Japan

Norwegian exporters began their marketing program with Japan in 1982, when they shipped 34 t of frozen salmon to that country. Exports remained under 1,000 t through 1986. In 1987, exports increased to 1,500 t and then nearly doubled to slightly less than 3,000 t in 1988. Norwegian salmon

exporters established a joint export company called "Unilaks" to promote frozen salmon exports to Japan in 1989. Shipments in that year reached 5,700 tons. Unilaks was organized by the fresh fish exporters and FOS, and it announced plans to increase exports to between 10,000 and 20,000 tons. Unilaks has, however, reported little success in reaching that goal. Norwegian exports of frozen salmon to Japan amounted to only 4,700 t in 1991,[118] less than was exported in 1989. Japanese consumers do not regard the Atlantic salmon as highly as they do Pacific salmon. Japanese consumers look for certain flesh, fat, and color characteristics associated with Pacific salmon. Norwegian genetic scientists are carefully studying the Japanese consumers' preferences when it comes to salmon. These scientists believe they can produce a salmon that satisfies the Japanese consumers tastes (fat content and red flesh tone). This is an area where Norwegian scientists hope to see some breakthroughs in the next few years.

f. Spain

Spain is a major European market for seafood, but until recently, the Spanish consumer had little familiarity of salmon. Norwegian exporters, however, realized that Spain was an ideal market; many north European consumers vacationed in Spain and it was natural that they would buy salmon products if these products were available. It was then only a matter of time before Spanish consumers --- with their love of seafood -- would also begin to order salmon. The effort began in 1982 with a modest shipment of less than 300 tons. By 1985, the amount exceeded 1,000 tons. Norwegian exporters initiated a $400,000 marketing program directed at Spain in 1987 and exports neared 2,000 tons. Norway began the marketing effort after receiving reports that Irish and Faroese competition were increasing their market in Spain. The program was aimed at restaurants in Madrid, Barcelona, and 11 other Spanish cities during April 1987. "Salmon Week" was later expanded to supermarkets throughout Spain and was aimed at boosting sales during the Christmas holidays. In 1991, Norway exported over 13,300 t of salmon to Spain which ranked as Norway's 4th largest customer. Interestingly, all of these shipments consisted of fresh and smoked salmon. The sale of fresh seafood, in particular, is very appealing to Spanish consumers.[119]

g. Sweden

Norway's neighbor, Sweden, was never a particularly large market for Norwegian salmon. However, in recent years, the Swedish market for Norwegian salmon has expanded as exporters attempt to find new markets for their product. The Swedes enjoy salmon and it is only natural that the market expand, particularly given short transportation distances and costs. In 1991, Sweden became Norway's third largest customer with imports exceeding 13,000 t worth $85 million. The purchases included over 9,100 t of frozen salmon worth $55 million and 288 t of smoked salmon worth $4 million. This suggests that Sweden became an important new market for much of the mountain of unsold frozen salmon in 1991. This, however, is not entirely true. In 1991, the freezing program resulted in freezing space in Norway being fully utilized; some of Norway's salmon had to be shipped to frozen stores in different countries. Large quantities of frozen salmon were sent to Sweden, Denmark, and Germany for storage. When the salmon crossed the border, it was registered by Norwegian Customs as exported. Later some of this salmon was re-exported from Sweden (Denmark and Germany). Thus, although official exports to Sweden suggest a large increase, these exports are slightly misleading since much of the salmon was later re-exported.[120]

h. United States

Norway began exporting fresh, farmed salmon to the United States in 1981 when 10 t were shipped to key gourmet restaurants.[121] A U.S. Government report prepared in 1983 indicated that the United States was an important market for Norwegian farmed salmon and that this high-quality product would become increasingly important in the U.S. and world markets in competition with U.S. Pacific salmon products.[122] The Norwegian strategy for entering the U.S. market was (1) to avoid competing with Pacific salmon during the summer months when prices decline and (2) to focus on the sale of fresh fish during the winter when prices are high. As part of their program to market their product, the Norwegians launched a program to identify Norwegian salmon as a luxury seafood served at "white-tablecloth" restaurants.[123] Norwegian farmed salmon sales to the U.S. and other traditional Pacific salmon markets increased dramatically during the 1980s, in some cases displacing Pacific salmon.

The U.S. market proved to be an excellent market for Norwegian exporters. Exports of farmed Norwegian salmon to the United States went from 20 t in 1981 to nearly 13,000 t in 1989. In 1990, the United States began anti-dumping and subsidy investigations against imported fresh Norwegian salmon; exports declined to 10,300 t in 1990 and then

declined sharply to 1,300 t in 1991 (valued at $13 million).[124] U.S. import of Norwegian farmed salmon (as compared with Norwegian export statistics) are summarized in table 2 and in the appendix section:

Table 2.--United States. Imports of fresh, frozen, and smoked salmon from Norway, by quantity, 1986-91.

Year	U.S. Imports	
	Quantity	Value
	Metric Tons	US$1 Million
1986	9,132	65
1987	7,831	59
1988	9,195	72
1989	13,665	85
1990	9,449	65
1991	1,319	13

Source: U.S. Bureau of the Census.

The U.S. market now accounts for only a small fraction of total Norwegian farmed salmon exports. Analysts cite various factors contributing to this decline, but the most important reason was the imposition of countervailing and anti-dumping duties by the United States. Other factors include: (1) increased competition from Canadian, Chilean, and Scottish salmon; (2) weakening of the U.S. dollar compared with the Norwegian krone; and (3) a slump in restaurant sales.[125]

i. USSR (Russia)

Norsk Hydro A/S shipped 10 t of frozen salmon to Kirovsk on the Kola Peninsula in 1991. The salmon was distributed as food aid to the 22,000 employees of the Soviet joint phosphate company P.O. Apatit. Norsk Hydro is 51-percent owned by the Norwegian Government and is involved in oil, metal, and chemical industries. The salmon came from the "mountain" of salmon withdrawn from fresh markets and frozen in early 1990 to maintain price stability.[126]

j. Others

Norway also has well established markets for its products in Belgium, the United Kingdom (a major competitor), the Netherlands and elsewhere. A recent new client is the Republic of Korea which purchased 175 t of frozen salmon in 1991. Other customers (not identified) purchased a total of 3,200 t of Norwegian product worth $23 million in 1991. It is expected that sales to Poland, Hungary, Israel, India, and some Middle Eastern and African nations will be reported in 1992.

B. Trade Disputes and Restrictions

1. European Community, 1990-92

a. Anti-dumping investigation

The European Community announced it would investigate Scottish and Irish complaints of alleged Norwegian subsidies and dumping on February 2, 1990.[127] Despite this announcement, exports of Norwegian farmed salmon during the first two months of 1990 were running well ahead of comparable exports in the previous year: 22,000 t of fresh salmon were exported compared with 13,500 t during the first two months of 1989. The value of 1990 exports was $98 million.[128] The EC concluded that fresh, farmed Norwegian salmon was sold to EC processors at between 20 and 30 percent below market price, causing Irish and Scottish salmon growers to lose an important share of the French market. The investigation also revealed that the sale of Norwegian salmon on the Danish black market had also affected Scottish and Irish producers. The Commission's investigators suggested that the EC should impose an anti-dumping duty of 11.4 percent on EC imports of Norwegian salmon imports.[129] The efforts of Norwegian salmon exporters to bolster export prices, however, reassured EC officials that the problem of low prices had been solved.[130] Accordingly, in November 1990, the EC agreed to drop the threatened EC import penalty.[131] This was based on the GON recognizing the need for avoiding market disruptions and its willingness to consult with the EC if disruptions did occur.[132] No sooner had the EC made its announcement, than the Scottish Salmon Growers' Association (SSGA) claimed that prices for Norwegian farmed salmon had again declined to "disastrous levels," and the SSGA called for a 21 percent import duty on Norwegian imports.[133]

The FOS responded to these complaints by announcing that it would continue to buy and freeze excess fresh salmon in 1991 if necessary to maintain or increase prices.[134] Scottish and Irish salmon growers, however, were not satisfied with the FOS efforts and alleged that measures taken during 1990 were not working. In April 1991, the SSGA again alleged that Norway was dumping farmed salmon on the EC market. Norway denied the charge and accused Ireland and Scotland of attempting to oust Norwegian farmers from the EC market. Irish salmon producers asked the EC to establish a salmon reference price as a protective measure.[135]

b. Minimum sales price

John Gummer, UK Minister of Agriculture, Fisheries and Food, in August 1991, expressed his concern with problems facing UK salmon farmers because of low-priced imports from Norway.[136] Scottish salmon farmers asked the EC Commission again during September 1991 for protection against alleged Norwegian dumping of farmed Atlantic salmon. These farmers complained that the Norwegians were selling salmon below Scottish production costs by as much as $1.00/kilogram. The Scots also alleged that the Norwegians were selling their products below their own cost of production. They based their claims on the fact that the Norwegians use similar methods and have the same basic cost structure as Scottish fish farmers. Norwegian authorities cite market conditions, not dumping, as the cause for low salmon prices. The arguments made by the Scottish and Irish salmon producers apparently worked; the EC adopted new minimum import prices for farmed Atlantic salmon on November 8, 1991 (Regulation 3383/91).

The minimum prices entered into force on November 2, 1991, and were in force until February 28, 1992. The EC renewed the minimum price scheme during March 1992, extending it until May 31, 1992[137]. The EC minimum prices reportedly were the same as those imposed by the FOS in their own markets before they went bankrupt. The Norwegian industry, however, was concerned about the minimum prices, as they represent a further difficulty for an already troubled industry in its principal market. EC representatives claim, however, that the minimum prices should not significantly change Norway's position as the dominant supplier to the EC salmon market. Indeed, the representatives claimed that the minimum prices should guarantee Norwegian exporters a more reasonable price than the market currently yields.[138]

2. United States

a. Subsidy investigation

U.S. salmon farmers culture both Pacific (*Oncorhynchus sp.*) and Atlantic salmon in Washington and Maine. The U.S. salmon farming industry in Maine began to feel the impact of lower salmon prices in 1989 when imports doubled from 22,600 t worth $155 million to 45,000 t worth $229 million.[139] It was not until Scottish and Irish salmon producers began demanding an investigation into allegations of "dumping" and "subsidies" that similar demands were made in the United States. On February 28, 1990, the "Coalition for Fair Atlantic Salmon Trade" (FAST), a group of 21 U.S. Atlantic salmon farmers, filed a petition with the U.S. International Trade Commission (ITC) and the U.S. Department of Commerce alleging that the Government of Norway was subsidizing its salmon aquaculture industry and that farmed Atlantic salmon from Norway was being sold at less than fair value.[140] Many Maine salmon farmers reported that decreasing Norwegian prices were adversely affecting their own sales and profits and that it was increasingly difficult for them to obtain bank loans.[141] The Norwegian Ministry of Foreign Affairs, however, insisted during March 1990, as the U.S. Government began its investigation,[142] that Norwegian farmed salmon was not subsidized and was not being "dumped".

The ITC determined on April 16, 1990, that there was a reasonable indication that U.S. salmon farmers were injured by imports of low-priced fresh salmon from Norway. On April 25, 1990, these determinations were published in the *Federal Register* (55 F.R. 17507). The International Trade Administration (ITA) of the Department of Commerce issued a "Preliminary Affirmative Countervailing Duty Determination" against fresh and chilled Atlantic salmon from Norway on June 21, 1990. The investigation found that Norwegian salmon producers and exporters had benefitted from subsidy programs, and imposed provisional duties of 2.43 percent *ad valorem* for all salmon exports.[143] The study found these subsidy programs to include: (1) regional development fund loans and grants, (2) National Fishery Bank of Norway loans, (3) regional capital tax incentives, (4) advance depreciation of business assets, and (5) government-funded research and development programs.[144]

b. Anti-dumping investigation

The U.S. Department of Commerce, on September 26, 1990, announced a preliminary affirmative anti-dumping determination and imposed provisional duties averaging 2.96 on imported fresh and chilled farmed Atlantic salmon from Norway. The ITC published a revised schedule for its final hearings on November 21, 1990.[145] Following these public hearings the ITC made its final ruling on February 25, 1991, when it determined that Norwegian farmed Atlantic salmon was sold at less than fair value in the United States. The Department of Commerce then announced company-specific, weighted-average

dumping margins:[146]

Table 3.--United States. Weighted average dumping margins, by company, against Norwegian exporters of farmed Atlantic salmon to the United States.

Company	Margin
	Percent
Chr. Bjelland	19.96
Domstein & Company	31.81
Fremstad Group	21.51
Hallvard Leroy A/S	31.81
Saga A/S	26.55
Salmoner A/S/	18.61
Sea Star International	15.65
Skaarfish Mowi A/S	15.65
Others	23.80

Source: U.S. International Trade Commission, "Fresh and Chilled Atlantic Salmon from Norway," USITC Publication 2371, Washington, D.C., April 1991, p. A-3 and Federal Register, Vol. 56, No. 37, Notices, February 25, 1991.

United States importers of fresh, farmed Atlantic salmon were required to post a cash deposit, bond, or other security in the amount of the dumping margin in order for these goods to enter the United States. This was in addition to the 2.27 percent *ad valorem* payment based on the net subsidy determined to have been paid by the Government of Norway to salmon farmers. The announcement of these tough penalties came as a tremendous shock to the Norwegian fish farming industry which had expected minor, if any, penalties. The U.S. International Trade Commission issued its final affirmative determination that the U.S. industry was being injured by imports of fresh Atlantic salmon from Norway in April 1991.

Norwegian officials immediately requested General Agreement on Tariffs and Trade (GATT) consultations with the United States.[147] One day later, on March 6, 1991, Counselor of Fisheries of the Norwegian Embassy, Kjell Raasok, and Deputy Director General of the Norwegian Ministry of Fisheries, Rut Harildstad, met with officials of the National Marine Fisheries Service (NMFS) to voice their concerns. The Norwegian Government felt that the average 24 percent anti-dumping duty constituted a *de facto* embargo on Norwegian salmon and they decried the severe effects this would have on the approximately 700 Norwegian salmon farmers dependent on export markets. They threatened to appeal the decision before a GATT panel.[148]

The U.S. salmon industry in Maine requested an investigation of the Norwegian Government's role in disposing of the frozen salmon "mountain" left by the FOS bankruptcy shortly after the GON announced that it would provide a $69 million loan to the consortium responsible for selling the fish. The U.S. salmon industry was concerned that this constitutes a subsidy to the industry and may therefore be GATT inconsistent. U.S. authorities requested a briefing from Norwegian authorities regarding their role in the sales. A representative of the Norwegian Department of Foreign Affairs met with U.S. representatives in early December 1991 to discuss the matter. The consortium which has undertaken to market the frozen salmon, headed by BP Nutrition subsidiary AquaStar, must sell more than 30,000 t of frozen salmon. According to a spokesperson for Aquastar, the sales effort has met with initial market interest.[149]

Norwegian salmon sales (all forms) to the U.S. slumped from 9,450 t (worth $64 million) during 1990 to only 1,320 t (worth $12 million)in 1991, while exports of fresh salmon went from 7,800 t worth $49 million during 1990 to 560 t worth only $3 million in 1991[150]. Norwegian sources blame the drop on the impact of U.S. anti-dumping and countervailing duties.

There is still resentment over the loss of the important U.S. market. The NFFA asked its Government to investigate "massive subsidies" from the United States to its Pacific salmon industry.[151] The Association also claimed that the United States was "dumping" Pacific salmon on the European market; U.S. Pacific salmon on the European market was reportedly sold as low as $1.87 per kilogram.[152] Some Norwegians believe that the U.S. salmon farming industry won only a minimal, short-term benefit from their litigation.[153] Some observers believe that the principal beneficiaries were Chile and Canada, and that low-priced Chilean salmon will depress prices far more than Norwegian overproduction. The Maine industry disagrees with this point of view. It has significantly increased its size and position in the U.S. market and believes that it would not exist today were it not for the relief they have received from the U.S. Government's anti-dumping and countervailing duty determinations.[154] Several visitors to the Norwegian pavilion at the Boston Seafood Show in March 1992 were concerned about low prices for Chilean salmon; they expressed an interest in seeing Norwegian salmon back in the U.S. market because of the "upscale, white-tablecloth" image of the Norwegian product.[155] The Norwegians, naturally, want to re-enter the U.S. market and would be willing to participate in a generic advertising campaign to promote farmed salmon.[156] However, this would require the Maine salmon farming industry

to drop its complaint, and this is something that the industry does not appear willing to do. In the absence of an amicable solution, the Norwegians also have the right to seek further court action or an administrative review which might be favorable. These approaches are not dependent on a withdrawal of the Maine salmon producer's complaint.

IV. OUTLOOK

Norwegian salmon farmers are attempting to reorganize their industry. During early 1992, Norwegian salmon farmers had to continue to sell their salmon at low prices simply to remain operational. Low operating margins have left little room for planning, and there has been no organization willing and able to assume the mantle of the defunct FOS. Though individual farmers are having difficulties, exports have remained high. As a result of low prices, exports of Norwegian farmed salmon reached 32,300 t by June 1992. This was 32 percent more than during the same six months of 1991.[157] Several analysts, however, indicated that the farmers anticipate strong demand for their product towards the end of 1992, and expect this anticipated increase in demand to shore up prices.[158] If this occurs, it could give Norwegian salmon farmers the room they need to invest in organization, new products, and marketing.

Norwegian producers were much less concerned in May 1992 about low price, however, than the possibility of EC anti-dumping duties on Norwegian salmon exports. Faced with continued complaints from Scotland and Ireland, the EC Commission may reconsider the anti-dumping duty option after the EC guide prices on Norwegian salmon expire on May 31, 1992. The prospect of EC duties causes great concern in the Norwegian salmon culture industry; effectively closed out of the U.S. market, Norwegian producers are highly dependent on sales to the price-conscious EC market. EC anti-dumping duties would be disastrous, severely constricting Norwegian salmon exports to the EC before the crucial Christmas season. Such an event could cause the most severe crisis to date in Norway's salmon culture industry.

A. Creating producers' organizations:

Despite these concerns, the salmon farmers are planning to create four or five producers' organizations based on the producers' organization system operating in the EC. This would provide Norway with the organizational and legal basis for export controls consistent with EC regulations. Not only might this forestall import restrictions from the EC, but increased organization of producers and exporters in Norway would help the industry behave and plan efficiently.

B. Market strategies for 1992-93:

The Norwegians have initiated a number of new measures designed to improve Norway's market position for 1992 and 1993.[159] These measures include:

- **Stricter quality control measures for all salmon exports.**
- **Stricter harvest limits.**
- **Re-establishing Norway's "white table cloth" image for its farmed salmon.**
- **Concentrating their marketing efforts on the salmon market in Spain.**
- **Developing new product lines, especially if prices for fresh salmon remain low.**

The short-term Norwegian strategy for 1992 was to reduce the "mountain" of frozen salmon. The industry reportedly reached this goal by mid-1992. Norwegian exporters have responded to strong consumer demand by selling record quantities of fresh salmon during the first 5 months of 1992. Of course, the problem to date has been that supply continues to outpace even the constantly growing demand for farmed salmon. NFFA officials believe that, because of decreases in Norwegian production, harvest shortfalls might appear by the end of the year (when demand and prices are traditionally highest). This would result in higher prices for salmon and may help Norwegian salmon farmers end the year on a profitable note.[160]

Norway's goal is to re-enter the U.S. market and the Norwegians are working for the abolishment of the duties on their fresh salmon. The Norwegian salmon industry has taken the case to GATT for dispute resolution. In both the U.S. case and the GATT case, it is expected that judgements will be rendered during the autumn of 1992. A major exporter of Norwegian salmon has also asked for an administrative review of the anti-dumping duties.[161]

Most Norwegian salmon observers concede that re-entering the United States market will be difficult; Chile has firmly established itself as the primary supplier of farmed salmon to the United States, and it will be difficult for Norway to displace Chilean exports. It is unclear, for example, if Norwegian producers can compete with the Chileans on a price basis. It is likely that Norway will take a dual approach to the U.S. market: (1) resume shipments of fresh salmon and (2) develop new, value-added products and then develop new markets for those products.[162]

One of the first steps taken to implement this strategy was the formation of a new export company, called *Norway Royal Salmon*. The company was created by 50 Norwegian salmon farmers and is headed by Odd Steinsbø, former FOS Managing Director. Norway Royal Salmon expects to manage 25 percent of all Norwegian salmon exports within a year. The company was created with a capital of over $80 million.[163]

Indications of some of the new directions that Norwegian salmon farmers may take began to appear at the ANUGA'91 international food show held in Cologne, Federal Republic of Germany in October 1992.[164] Leroy Seafood, a participant at the Norwegian pavilion, displayed a range of value-added frozen salmon products, including steaks, butterflies, loins, and fillet portions. Other products designed specifically for caterers include whole tails, skin-on or skinless tail portions, and a product called "tartar/chute" which is used to prepare soups, mousse, pâtés, or salmon tartar. The company has also developed markets for salmon roe and the fat taken from the belly of the salmon; these are placed in 5-kg boxes for shipment to Denmark. Another company, Arctic, is preparing salmon schnitzels and salmon burgers. These products were tested in Norway and are now ready for export markets. A smoked salmon roll was exhibited by Leica Fiskeprodukter of Norway and consisted of smoked salmon, eggs, and spices that are wrapped in cellophane in 500 g or 1,000 g sizes. The roll is simply thawed and served as sliced salmon. The Stabburet company has introduced a salmon pâté called "Laksepostei" in a 100 g can which is being sold in Norway.

Erik Hempel, a noted authority on Norwegian salmon farming, has spoken with several leading observers about the future of Norway's salmon industry. He is confident that Norway has reached a "turning point" in the salmon market. Although prices in 1992 have been lower than during 1991, many now see a shortage of salmon appearing. There is very little frozen salmon left and many of the smolts put into pens in 1990 have been harvested. This suggests that the era of overproduction has come to an end. Modest price increases -- estimated about around $1.00 per kilogram -- are anticipated.[165]

C. New fish farming technology

Norwegian scientists now have the technical expertise to breed salmon designed to appeal to specific markets. These salmon, for example, might be raised with the fat content and color which Japanese consumers prefer. This would allow Norwegian producers to better tailor their marketing efforts in the future. These same scientists are working to increase resistance against diseases,[166] increase growth through improved utilization of feedstuffs,[167] and to decrease the number and occurrence of grilse (salmon which reach sexual maturity early, before they reach market size).[168]

V. GOALS

Norway has fairly detailed goals for the development of aquaculture. These Government goals are usually submitted to the Norwegian National Assembly (or Storting).

The *Summary of Report Nr. 65 (1986-87) to the Storting on Aquaculture* submitted in 1986, stated the Government's main goal is to "promote the development of a profitable, viable and economically independent regional industry." The report went on to identify 3 subgoals: (1) to ensure good growing conditions for intensive cultivation of salmon and trout; (2) to extend the scope of the industry by introducing the cultivation of new species (cod, halibut, marine catfish/wolfish, lobster, Arctic char, and several species of shellfish); and (3) to develop sea ranching.[169] This policy was followed between 1986 and 1990, although results on sea ranching have not been as visible as efforts in other areas.

The Norwegian Ministry of Fisheries modified these goals in 1990. The three goals for Norwegian aquaculture were: (1) diversification of salmon farming into new types of fresh and frozen salmon products, including development of a range of high quality processed salmon products; (2) farming of

different species, including **Arctic char, Atlantic halibut, cod, oysters, scallops, turbot**; and **wolfish**[170] (3) sea ranching of salmon, char, cod, and Norway lobster.[171] These goals were similar to those announced in 1988, but expressed a new desire to produce innovative, value-added seafood products.

VI. SUMMARY

Norway has the capacity to boost annual harvests of farmed Atlantic salmon to 720,000 t according to the "Lenka Report," prepared by the Ministry of Fisheries and the Ministry for the Environment.[172] The Norwegian Minister for the Environment, Kirstin Hille Valla, commented that environmental and other problems related to fish farming would have to be addressed before renewed expansion could be considered.[173] It is unlikely that Norway will ever reach its full aquacultural productive capacity; Norwegians are raising environmental and aesthetic considerations, and Government is considering limits to the industry's expansion. Nevertheless, Norway still has the capacity to significantly increase production, and might realize harvests as high as 400,000 t after the turn of the century.

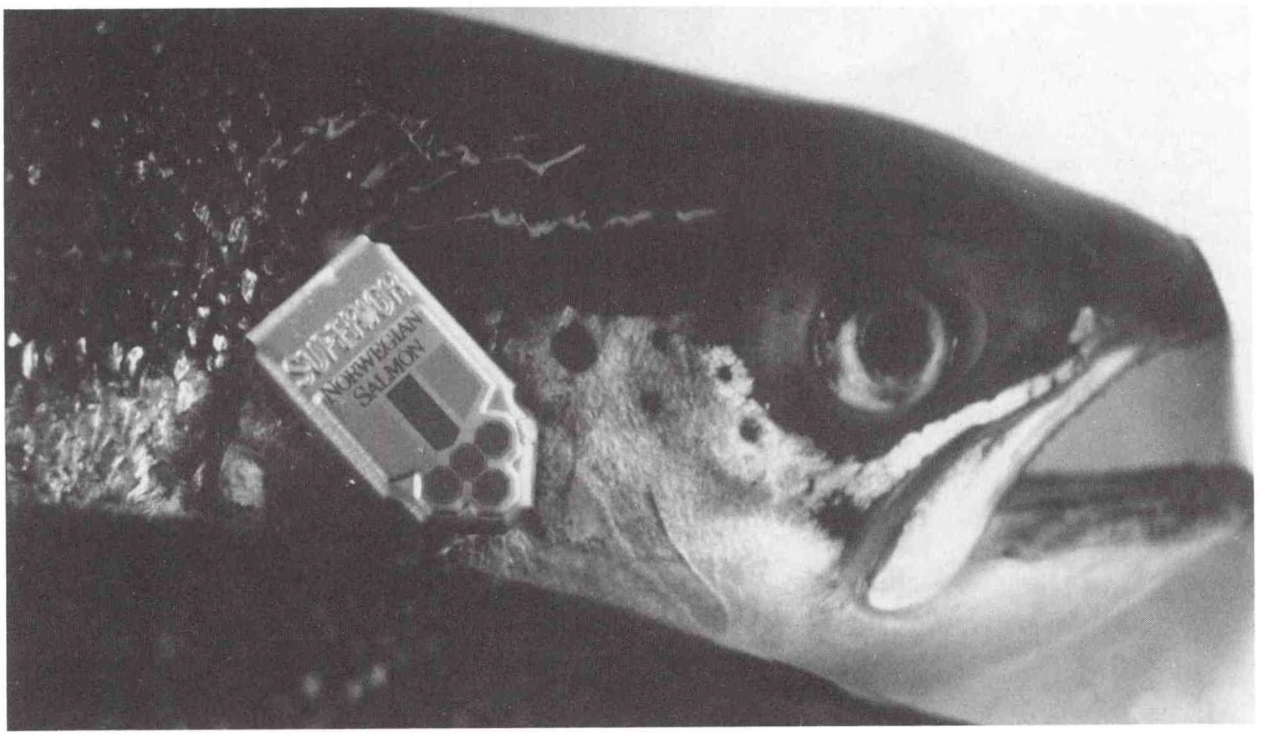

Figure 12.--Farmed Norwegian salmon with gill tag.

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GLOSSARY OF TERMS, ACRONYMS, AND ORGANIZATIONS.

AKVAFORSK: Institute of Aquaculture Research. Established by the Agricultural Research Council of Norway. Operates research stations at Ås, Averøy, and Sunndalsøra.

FOS: Norwegian Fish Farmers Sales Organization. Established in 1978 with the sole responsibility for marketing farmed salmon. Also abbreviated as NFFSO.

Hitra disease: a salmon disease caused by a cold-water vibrosis. The disease first appeared in Norway in 1984 and is named after a Norwegian island.

MCFF: Marketing Council for Farmed Fish. A marketing organization with members of the FOS and NECF. The Council promotes marketing of farmed Norwegian fish.

Marketing Council for Farmed Fish (MCFF). A marketing organization with 3 members of the FOS and 3 members from the Norwegian Export Committee for Fresh Fish. The Council promotes marketing of farmed fish.

NECFF. The Norwegian Export Committee for Fresh Fish. A marketing organization promoting the export of fresh Norwegian fish.

NFFA: Norwegian Fish Farmers' Association. An industry organization to promote salmon aquaculture in Norway.

Norwegian Export Committee for Fresh Fish (NECFF): a marketing organization promoting the export of fresh Norwegian fish.

Norwegian Fish Farmers' Association (NFFA): an industry organization to promote salmon aquaculture in Norway.

Norwegian Seafood Export Council: was established in July 1991, to take over the activities of the Marketing Council for Norwegian Salmon.

EXCHANGE RATES:

US$1.00 = Norwegian krone (NOK)

1992 =	6.00 NOK
1991 =	6.56 NOK
1990 =	5.78 NOK
1989 =	6.81 NOK
1988 =	6.48 NOK
1987 =	6.43 NOK
1986 =	7.38 NOK
1985 =	8.57 NOK
1984 =	8.16 NOK
1983 =	7.30 NOK
1982 =	6.45 NOK
1981 =	5.74 NOK
1980 =	4.94 NOK

ENDNOTES

SECTION I (Overview)

1. *Norway Salmon Yearbook, 1991,* Trond Wold, Editor, AquaSeed Press, Inc., Seattle, WA. 1991, p.2.

2. Kari Bjørbæk and Erik Hempel, "The status of Norwegian salmon farming," *INFOFISH International*, 2/88, pp.26-29, Eivind Dale, Jonathan Owens, Asmund Stenseth, *A dyrke havet*, Gruppen for Ressursstudter, Soldo, Norway, July 1986 (translation entitled "Tilling the Sea - Prospects for Norwegian Aquaculture"), and personal observations and discussions.

3. An exceptionally good description of the biology of Atlantic salmon is provided by Stephen Drummond Sedgwick, *Salmon Farming Handbook.* Fishing News Books Ltd., Farnham, Surrey, England, 1988.

4. There are, however, isolated land-locked forms of Atlantic salmon. The Danube salmon (*Hucho hucho*), found the in Danube River in Europe, is sometimes identified as a salmon and this small, isolated population frequently, and incorrectly, appears in trade statistics from various European countries. North American biologists consider *Salmo salar* to have the taxonomy of a trout. European biologists, however, insist that *Salmo salar* is the only species which should be referred to as a salmon.

5. Pacific salmon species die shortly after returning to their natal streams and spawning.

6. Fish that return after only 1 year at sea are called "grilse" and usually weight 1.5 to 2.5 kilograms. In the wild, the grilse account for about 30 percent of all smolts.

7. These traits include fast growth, a desired level of fat content, flesh color, muscle tone, resistance to diseases, etc. Original broodstock are based on wild specimens and then carefully husbanded for several generations before being replaced. Broodstock are also selected from specific year classes that demonstrate special traits. Smolts that survived exposure to furunculosis, for example, were selected as broodstock when they reached maturity. Eventually it is helpful to re-introduce wild stocks to the captive breeding stock to prevent inbreeding and to maintain genetic diversity.

8. In recent years, the time taken to reach the smolt stage has gradually been reduced and is now about 6 months.

9. Sexual maturation in salmon involves the utilization of body fats, protein, and carbohydrates to create eggs and milt. These fats also contain concentrations of carotenoids which provide the salmon's characteristic pink or red color. As the salmon's nutrients are depleted to produce roe or milt, the flesh becomes pale, watery, and tasteless. The fish are safe to eat at this time, but are no longer premium quality. See: Stephen Drummond Sedgwick, *Salmon Farming Handbook.* Fishing News Books Ltd., Farnham, Surrey, England, 1988. p. 22-23.

10. Trond Bjørndal, *Industrial Structure and Cost of Production in the Norwegian Aquaculture Industry*, Fundacion Chile, Santiago, Chile, March 17-19, 1987, pp. 2-3.

11. Hitra disease is in fact named for the island where the first serious outbreak of this disease occurred during 1985. The disease was first documented in northern Norway during 1980.

12. The Norwegian Fish Farmers Association reported the figure as 200 million NOK in their publication entitled *The Norwegian fish farming industry in harmony with the environment.*

13. Boxaspen, Karin. *PYRETRUM - Et naturlig insekticid og mulig middel mot lakselus*, Havforskningsinstitutte, Senter for Havbruk, Bergen, November 1990.

14. NORINFORM, January 23, 1990.

15. *Fish Farming International*, July 1991.

16. Personal discussions with scientists at the Institute of Aquaculture Research in Sunndalsøra on May 13, 1992.

17. Edwards, David. "Eggs from the Bank." *Fish Farming International*, December 1978, pp. 34-35.

18. "Norwegians Breeding 'New' Salmon, *Fishing News*, January 12, 1979.

19. The Norwegian Fish Farmers Association notes that the European Salmon Growers Association has debated the use of recombinant hormones and genetic manipulation of salmon for human consumption and has published strong resolutions against this. The first resolution was announced in 1986. The 1991 general assembly of the European Salmon Growers Association passed a resolution that was labeled as clearly illegal and potentially damaging to the marketing of salmon. The 1991 resolution was again confirmed in 1992. *Norsk Fiskeoppdrett*, No. 6/92, p.49 and Leif Magnar Øveraas, Manager, Public Affairs Department, Norske fiskeoppdretteres forening (Norwegian Fish Farmers Association), fax dated July 30, 1992.

20. AKVAFORSK, *Årsmelding 1991*, Institutt for akvakulturforskning, 1992.

21. Visit to the facility on May 13, 1992.

22. "Norwegians to Begin Selective Breeding," *Fish Farming International*, November 1986.

23. *Fish Farming International*, February 1991. A good examination of Norway's concern about the impact of fish farming on the environment is found in the Norwegian Fish Farmers Association's *The Norwegian Fish Farming Industry in Harmony with the Environment*, Trondheim, 1990.

24. Duane Kelly, *Pacific Fishing, op. cit.*, p.54.

25. Brooker, *op. cit.* The use of shrimp offal by the salmon farming industry is very beneficial to Norway's shrimp industry, since 70 to 75 percent of the landed weight of shrimp consists of waste products (i.e., the head and shell).

26. Brooker, *op. cit.*. The figure is thought to include all fish farms and not just salmon farms.

27. Dr. Trond Storebakken, Senior Scientists (Nutrition) at the Institute of Aquaculture Research, at Sunndalsøra, discussed recent developments in salmon nutrition during a visit to the AKVAFORSK research station . See also: "Bright Future is Seen for Salmon Farms, Feeds and Feeding, *Fish Farming International*, March 1980, p.14.

SECTION II (Salmon Harvests)

28. Duane Kelly, "Salmon Farming, Norwegian Style," *Pacific Fishing*, November 1984, p. 54.

29. U.S. Embassy, Oslo, May 29, 1986.

30. Jensen, Arne. *Å Dyrke Havet--Perspektivanalyse for norsk havbruk* (translated as "To Cultivate the Sea -- Perspective Analysis for Norwegian Aquaculture"), Norges Teknisk-Naturvitenskapelige Forskningsråd (Norwegian Technical-Scientific Research Council), Trondheim, May 13, 1985.

31. The move apparently succeeded in stimulating growth in the industry. *Fish Farming International*, in October 1985, featured an article entitled "Norwegian Investors Rush to Buy Salmon Shares" noting that Sea Farm A/S (a major smolt producer) had offered 10 kroner shares to investors at 220 kroner per share and the issue was immediately oversubscribed by 73 percent!

32. Bjørndal, Trond. "The Norwegian aquaculture industry - Industrial structure and cost of production," *Marine Policy*, April 1988, p. 124. The numbers of smolt producers and harvest includes both salmon and trout.

33. Bjørndal, *op. cit*, p. 124.

34. U.S. Embassy, *op. cit*, May 29, 1986.

35. Norske Fiskeoppdretteres Forening, *Årsberetning og Regnskap 1986*, Trondheim, p. 6.

36. Fiskeridepartementet informerer, *Summary of Report Nr. 65 (1986-87) to the Storting on Aquaculture* (English translation).

37. The cost of smolts weighing 30 grams was about $2.00 in 1984. James R. Brooker, "A Report on Aquaculture Activities in Norway," Office of Utilization Research, National Marine Fisheries Service, Washington, D.C., July 1984.

38. Kari Bjørbæk and Erik Hempel, "Norwegian Farm Future is Still Bright," *Fish Farming International*, March 1988, pp. 18-19, p. 34. The authors went on to report that "smolt supply does not appear to be a bottleneck for Norwegian farmers" at the start of 1988.

39. Smolts are raised in pens until they reach "market size", which is between 2 to 4 kilograms. At that point they are usually harvested, but some fish are harvested when they reach 6-7 kilograms. In the development of this report we estimated that one million smolts typically would yield 2,000 metric tons of market-sized fish. A one-to-two conversion figure is only one method to gauge the approximate final weight of market-sized fish based on the number of individual smolts. We recognize that other conversion figures (e.g., 1:3) can be used that are more accurate. Losses from natural mortality, stress, disease, escapement, and differing market sizes affect the final production and our conversion ratio can only serve as a "general guideline".

40. Odd Steinsbø, *Norwegian Salmon Industry*, speech given at Salmon'90, Trondheim, Norway, May 8, 1990 reported that Norway stocked 73 million smolts into grow-out pens in 1988. Based on a 1:2 conversion ratio, 73 million smolts would normally yield 146,000t two years later; Norway's 1990 harvest was 145,990 tons.

41. Odd Steinsbø, chief executive of the Fish Farmers Sales Organization warned the Norwegian salmon farming business of the danger of overproduction of smolts in late 1986. In *Fish Farming International*, March 1987, p. 7, he was quoted as saying: "Our forecasts clearly show that we shall have a large surplus of smolts as early as this year." He warned that the availability of too many smolts could create an upward spiral that would be financially disastrous for many in the industry. His words were unusually prophetic. The actual 1990 catch was closer to 158,000 tons.

42. Steinsbø, Norwegian Salmon Industry, *op. cit.*, p. 3.

43. A good description of the problem with Norway's smolt production was prepared by Pat Keogh, Deputy Executive of the Irish Sea Fisheries Board in an article entitled "Global trends for farmed salmon," *Seafood International*, February 1991, p. 54.

44. *Fish Farming International*, June 1991.

45. This indicates that there were 75 million smolts available in 1991. This suggests that there might have been more smolts available in 1990 than was reported by the NFFA.

46. Torben Foss, Director General of the Royal Norwegian Ministry of Fisheries, personal communications in February 1992 as part of discussions held with the U.S. Special Trade Representatives Office in Washington, D.C.

47. Berg, Odd. "History of the Norwegian Fishfarming Industry - Organization and Operation," speech given at "The VIII Week of Fisheries", sponsored by the Regional Government of the Azores, prepared in Trondheim on March 2, 1988.

48. Berg, Odd. *"Historyof the Norwegian Fishfarming Industry - Organization and Operation,"* speech given at "The VIII Week of Fisheries", sponsored by the Regional Government of the Azores, prepared in Trondheim on March 2, 1988, p.3.

49. Berg, Odd. *"Historyof the Norwegian Fishfarming Industry - Organization and Operation,"* speech given at "The VIII Week of Fisheries", sponsored by the Regional Government of the Azores, prepared in Trondheim on March 2, 1988, p.2.

50. Brooker, *A Report on Aquaculture Activities in Norway,op.cit.*

51. It typically takes several months to begin operations after obtaining a license. It then typically takes two years after stocking smolts before a farmer can begin harvesting market-sized salmon. This accounts for the difference between the number of licenses issued during a specific year and the number of fish farms in operation.

52. E. Evan Brown, Ph.D., Professor, University of Georgia. *World Fish Farming: Cultivation and Economics.* (AVI Publishing Company, Inc.: Westport, Connecticut, 1983), p. 83. This has been reported in other sources. However, some sources report that the law restricting farms to 8,000 cubic meters was enacted in 1985.

53. "Fishing future may be in farming," *Fishing News International*, October 1984, p. 5.

54. Dale, Owens, and Stenseth, *Tilling the Sea*, p. 15.

55. Office of Industry Services, *Trends in Norway's Aquaculture Industries: Implications for the United States*, National Marine Fisheries Service, NOAA, U.S. Department of Commerce. Unpublished report dated August 16, 1983.

56. "Norway Farm Salmon Topped Only by Cod," *Fish Farming International*, March 1985.

57. "Norway Farm Salmon Topped Only by Cod," *Fish Farming International*, March 1985.

58. Brooker, *op.cit.*

59. Dale, Owens, Stenseth, *Tilling the Sea*, *op.cit*, p.4.

60. Dale, Owens, Stenseth, *Tilling the Sea*, *op.cit*, p.4.

61. Dale, Owens, Stenseth, *Tilling the Sea*, op.cit, p.4. However, *Eurofish Report*, in their issue of September 27, 1984, reported that the limits imposed by the Government of Norway meant that large salmon firms, such as Mowi A/S and Sea Farm (Stolt-Nielsen) found prospects for expansion too limited and thus they began to establish fish farms overseas.

62. "Europe: Norway," *Seafood Leader*, Spring 1985, p. 48: "We have seen the enemy and it is us. More and more, Norway's salmon farmers will find themselves competing for market share with Norwegian companies that have set up Atlantic salmon farming operations in countries that are more interested in promoting the growth of a salmon farming industry than limiting it, as is the case in Norway." "Norway Farm Salmon Topped Only by Cod," *Fish Farming International*, March 1985. See also: James L. Anderson and Patricia Lavin Reily, *The Status of Atlantic Salmon Aquaculture*. Department of Resource Economics, The University of Rhode Island, NOAA/Sea Grant Marine Technical Report 92, March 1986, p.8.

63. Trond Bjørndal cited the example of one Norwegian fish farm, A/S Einvikfisk, which began in 1985 with 500 shares worth 1,000 kroner apiece. In January 1985, the company issued 199 new shares; these shares were purchased for 4.7 million kroner, almost 24 times more than their nominal value! In August 1985, additional shares were offered to investors at 45 times the normal value of the shares!" Bjørndal, *op.cit.*, pp.125-126 and "Norwegian Investors Rush to Buy Salmon Shares," *Fish Farming International*, October 1985, p. 2,

64. Bjørndal, *op.cit*, p.127.

65. Steinsbø, Odd, *Keynote Report - Norway*, JETRO International Forum on Salmon and Trout, 1987. This speech was apparently delivered in Japan in 1987.

66. Bjørbæk and Hempel, "Norwegian Farm Future is Still Bright," *op. cit.*, p.18.

67. Kari Bjørbæk remained with the Ministry of Fisheries and was Deputy Director General in the Ministry of Fisheries in May 1992. Mr. Hempel is Managing Director of Hempel Consult A-S.

68. Pat Keogh, "Global trends for farmed salmon," *Seafood International*, February 1991, p. 55.

69. U.S. Embassy, Oslo, July 10, 1988.

70. U.S. Embassy, Oslo, July 10, 1988.

71. U.S. Embassy, The Hague, April 11, 1989.

72. *Eurofish Report*, February 15, 1990.

73. Thor Mowinckel noted that Saga Seafood was still in a developmental stage when low prices and other mishaps forced it into bankruptcy. *Fish Farming International*, July 1989.

74. *Fish Farming International*, July 1989.

75. U.S. Embassy, Oslo, August 14, 1989.

76. "Bankruptcy hits 10 percent in Norway," *Fish Farmer*, September/October 1990, p. 24.

77. The Norwegian Fish Farmers Association's estimates did not agree with the projection made by the FOS. According to a NFFA survey, Noway's 1989 smolt production (which contributed to the 1990/91 harvest) was estimated at 83 million smolts. The FOS survey conducted at about the same time, concluded that salmon farmers would only put 66 million smolts into the sea. The NFFA contacted the Government of Norway to determine if a smolt producers' organization could be organized, which could finance the destruction of surplus smolt. This was not possible. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, fax dated July 30, 1992.

78. *Fish Farming International*, November 1989.

79. Some Norwegian salmon farmers may have kept their salmon in their pens hoping that the situation would improve in 1990. Thus, the 1989 harvest could have been slightly larger than the 115,000t reported.

80. Sales had reached 100,000 t by the autumn and FOS projections called for 1989 exports to reach 115,000 tons. U.S. Embassy, Oslo, November 14, 1989.

81. Royal Ministry of Foreign Affairs, *Memorandum*, Oslo, March 1, 1990.

82. Royal Ministry of Foreign Affairs, *Memorandum*, Oslo, March 1, 1990.

83. U.S. Embassy, Oslo, January 11, 1990.

84. "Norway cuts production of fresh salmon," *Seafood International*, February 1990, p. 19.

85. "Norwegian Plan to Freeze 40,000 Tons Could Put Pressure on Frozen Salmon," *Quick Frozen Foods International*, April 1990, p.98.

86. *Fish Farmer*, "Bankruptcy hits 10 percent in Norway" September/October 1990, p. 24.

87. U.S. Embassy, Oslo, May 8, 1991.

88. *Eurofish Report*, September 26, 1991.

89. Peter Redmayne, "Norway'sSalmon Industry Shatters into Chaos," *Seafood Leader*, January/February 1992, p.75.

90. The FOS reportedly froze 40,000 t of salmon in 1990 and was attempting to do the same in 1991 when it went bankrupt, leaving 37,540 t unsold in cold storage.

91. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, fax dated July 30, 1992.

92. NORINFORM, November 19, 1991.

93. These were only promises. No financial or other significant contributions were made. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, fax dated July 30, 1992.

94. Kreditkassen, Den Norske Credit Bank, Sparebanken Nord-Norge, Sparebanken Nordland, Nordlandsbanken, Sparebaken Midt-Norge, Fokus Bank, Sparebanken More, Sparebanken Sogn og Fjordane, and Og Sparebanken Vest.

95. *Eurofish Report*, November 21, 1991.

96. *Eurofish Report*, December 5, 1991.

97. *Eurofish Report*, December 19, 1991.

98. Personal discussions with various officials of the Ministry of Fisheries in Oslo, Norway in May 1992.

SECTION III (Exports and Markets)

99. Fiskeridepartementet informerer, *Summary of Report No. 65, op. cit*, p. 14-15.

100. *Eurofish Report*, May 21, 1992, p. FS/2 and *NORINFORM*, June 2, 1992.

101. Personal discussions with Halvard P. Johanse, Jonny Didriksen, and Roald Paulsen, The Royal Ministry of Fisheries, Oslo, Norway in May 1992.

102. *Ibid.* Harvests of farmed salmon are expected to reach 119,700 t in 1992 according to discussions with Norwegian Government officials in May 1992. *NORINFORM* reported that exporters were expecting a 20,000 ton shortfall by the end of 1992.

103. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, fax dated July 30, 1992.

104. Leif Magnar Øveraas of the Norske Fiskeoppdretteres Forening (Norwegian Fish Farmers Association), indicated that the NFFA members would continue to rely on the export of fresh salmon, despite signs that frozen, value-added salmon products might be more appropriate. This was in the context of Norwegian exports of frozen, value-added products to the United States instead of shipments of fresh salmon, which were subject to import tariffs in 1991-92.

105. Sales of 15,000 to 20,000 t of frozen salmon were normal in the years just prior to 1990. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, fax dated July 30, 1992.

106. U.S. Embassy, Oslo, December 10, 1990.

107. Personal communications with Erik Hempel, Hempel Consult on July 12, 1992.

108. *Eurofish Report, op.cit.*, p. FS/1.

109. Birger Larsen, Royal Norwegian Embassy, personal discussions in June 1992. Erik Hempel, writing for the May 1992 issue of *Seafood International*, reported that 15,500 tons of frozen salmon remained unsold and that some of the oldest was beginning to turn rancid. The article cited Freddy Iversen of the Directorate of Fisheries in Bergen as confirming that the quality of the frozen salmon was deteriorating, although the quality remained "surprisingly high." The salmon is being stored at a very low temperature and there is concern that the salmon will not keep for long when introduced into supermarkets which are unable to maintain the fish at very low temperatures. See: Erik Hempel, "Challenging Times Ahead," *Seafood International*, May 1992, p. 27.

110. *Eurofish Report, op.cit.*, p. FS/1. Unverified reports suggest that some of the product sold to Poland was re-exported to the Federal Republic of Germany. Officials of the Ministry of Fisheries were aware of the possibility of re-exports and had taken steps to prevent this from taking place. William Crowe of the Scottish Salmon Growers' Association told *Eurofish Report* that he had received reports that some Norwegian frozen salmon was "leaking into Germany via Eastern Europe." No details were provided to substantiate this claim. "Tensions Persist Between Norwegian and EC Salmon Farmers," *Eurofish Report*, June 18, 1992.

111. Danish companies bought only 22,000 tons of Norwegian salmon worth about $134 million in 1991, according to Danish trade statistics. This is nearly 10,000 tons less than the 32,800 tons reportedly exported by Norwegian export statistics. It is possible that some of this might include "black market" salmon shipped to Denmark outside of normal channels. "Danes Profiting from Norwegian Salmon Exports," *Eurofish Report*, June 18, 1992.

112. Denmark imported 32,400 tons of salmon and large trout in 1991. Danish fish farmers produced 6,000 tons of large trout, giving Denmark a total of 38,400 tons. Domestic consumption was estimated at around 12,000 tons, leaving 26,000 tons available for export. Approximately 6,400 tons were sold as smoked product and the rest was sold fresh. The value of Danish salmon and trout exports was about $250 million in 1991 (1.4 billion Danish kroner) or about $70 million (400 million Danish kroner) more than they paid for their imports of salmon and trout. "Danes Profiting from Norwegian Salmon Exports," *Eurofish Report*, June 18, 1992.

113. *Infofish*, April 15, 1991.

114. Personal communication with Erik Hempel, Hempel Consult on July 12, 1992.

115. The amounts were: 1,156 kilograms in April, 2,704 kgs in May, 9,585 kgs in June, 28,029 kgs in July, and 77,082 kgs in August 1991. The product consisted of fresh and chilled farmed Atlantic salmon (product codes: 0302.12.00002,00003, and 00062).

116. "Danes Profiting from Norwegian Salmon Exports," *Eurofish Report*, June 18, 1992, p. FS/1.

117. Personal communications with Erik Hempel, Hempel Consult, July 12, 1992.

118. *Fish Farming International*, May 1989.

119. *Pesca-Peru*, July/August 1987 and *Industrias Pesqueras*, April 1, 1987.

120. Personal communications with Mr. Erik Hempel, Hempel Consult, on July 12, 1992.

121. *National Fisherman*, June 1984, p. 32.

122. *National Fisherman*, June 1984, p. 32.

123. *National Fisherman*, June 1984, p. 32.

124. Based on U.S. Bureau of the Census import statistics.

125. U.S. Embassy, Oslo, December 10, 1990.

126. U.S. Embassy, Oslo, December 24, 1990.

127. *Official Journal of the European Communities*, a notice of intention for an anti-dumping proceeding concerning imports of fresh Atlantic salmon from Norway (No. C 25/6).

128. *NORINFORM*, March 20, 1990.

129. "EC upholds Norwegian salmon dumping charge," *Fishing News*, October 12, 1990.

130. Regulation (EEC) No. 2423/88.

131. The *Corrigendum to Commission Decision 91/142/EEC of 15 March 1991 terminating the anti-dumping proceeding concerning imports of Atlantic Salmon originating in Norway* was published in the *Official Journal of the European Communities* on March 21, 1991, officially ending the EC anti-dumping investigation.

132. *NORINFORM*, November 20, 1990 and *Eurofish Report*, December 6, 1990.

133. *Eurofish Report*, December 6, 1990.

134. U.S. Embassy, Oslo, January 17, 1991.

135. *Eurofish Report*, June 20, 1991.

136. "UK concern over prices," *Fish Farming International*, September 1991, p. 42.

137. The EC apparently decided not to extend the minimum import prices on Norwegian salmon after the legislation lapsed on May 30, 1992. An EC spokesman did, however, confirm that the EC would not hesitate to reintroduce the legislation if it was necessary to protect Scottish and Irish salmon growers. *Eurofish Report*, June 4, 1992, p.BB/2. Commission Regulation No. 1561/92 published on June 18, 1992 amended EC Regulation No. 1658/91 establishing a surveillance system for imports of Atlantic salmon. The new regulation extended the surveillance arrangements for six months, until December 31, 1992. The action was taken to allow monitoring of the trend of Atlantic salmon imports to forestall any further deterioration of markets.

138. Trond Wold, Deputy Secretary General of the Norwegian Fish Farmers' Association apparently agreed when he stated that the NFFA would like to see the minimum import prices extended for another three months. *Eurofish Report*, June 4, 1992, pp. FS/2.

139. *Fisheries of the United States,* National Marine Fisheries Service, NOAA, U.S. Department of Commerce, Silver Spring, MD, various years.

140. Mark L. Hermann, Biing-Hwan Lin, and Ron C. Mittelhammer. "Consequences of Tariffs Placed on Norwegian Farmed Atlantic Salmon by the United States and the EEC," *Salmon Market Newsletter*, September 1990.

141. Michael Coursey, personal communications.

142. *NORINFORM*, March 20, 1990.

143. The final determination imposed a countervailing duty of 2.27 percent (slightly below the 2.43 imposed provisionally on June 21, 1990).

144. U.S. International Trade Commission, *Fresh and Chilled Atlantic Salmon from Norway*, USITC Publication 2371, Washington, D.C., April 1991, p. a-2.

145. "Revised schedule for the subject investigations," *Federal Register*, Vol. 55, No. 225, Notices, November 21, 1990.

146. "Final Determination of Sales at Less than Fair Value: Fresh and Chilled Atlantic Salmon from Norway," *Federal Register,* Vol.56, No. 37, Notices, February 25, 1991.

147. A cable reporting that the Embassy had been informed of the Norwegian Government's request on March 5, 1991. U.S. Embassy, Oslo, March 6, 1991.

148. "New Import Tax on Salmon Puts U.S.-Norwegian Relations at Stake," *Norway Times*, February 28, 1991. p. 3.

149. *Eurofish Report*, December 5, 1991.

150. U.S. Bureau of the Census import statistics.

151. The industry claimed that the U.S. Government and State of Alaska provides smolts for release into the Pacific Ocean and that amounts to a subsidy of the wild Pacific salmon industry. See "Norwegian-US salmon war," *Seafood International*, February 1992, p. 11. Maine salmon farms report that they have never received any subsidies from the U.S. Government and they were not selling any of their products in Europe in 1992.

152. Landings of Pacific salmon were unusually high in 1991 and prices to U.S. fishermen sank to very low levels. It was reported that pink salmon was so abundant that fishermen were using them as bait for other fish species. It is likely that frozen U.S. Pacific salmon was sold at low prices in Europe. It is unlikely, however, that these frozen Pacific salmon competed in the same market as the Norwegian farmed salmon. See also "Norwegian-US salmon war," *Seafood International*, February 1992, p. 11.

153. Several individuals mentioned this during my visit to Norway during the week of May 11-14, 1992.

154. Personal communication with Michael J. Coursey, Collier, Shannon, Rill & Scott, on August 6, 1992.

155. This apparently was not idle chatter. Norwegian salmon exporters shipped 15 tons of fresh salmon to the United States in early June 1992. This was the first large consignment to the U.S. in a long time. "Norwegian Salmon Exports to the U.S. Resume," *Eurofish Report*, June 18, 1992, p. FS/1.

156. Personal discussions with various industry and government officials in Norway during the week of May 11-14, 1992.

SECTION IV (Outlook)

157. *NORINFORM*, June 2, 1992.

158. Dag Koteng, of the Federation of Norwegian Fishing Industry, indicated that the EC would have a 20,000 ton shortfall in salmon by the end of 1992. *NORINFORM*, June 2, 1992.

159. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, personal communications, May 11, 1992. Mr. Øveraas notes that these measures will be the responsibility of the Eksporttutvalget for fisk (Noway's new export marketing organization).

160. Leif Magnar Øveraas, Manager, Public Affairs Department, Norwegian Fish Farmers Association, personal communications, May 11, 1992.

161. Trond S. Paulsen, Advokat, (Attorney-at-Law), Advokatfirmaet Heggemsnes & Paulsen, personal communications, May 14, 1992 and July 15, 1992. The case has been appealed to the Court of International Trade in New York, While an exporter has asked for an administrative review of the dumping determination of the U.S. Department of Commerce, it will also be an option to ask the U.S. International Trade Commission to review the case based on changed circumstances.

162. Discussions with officials of the Norwegian Ministry of Fisheries, the Norwegian Fish Farmers Association, private salmon farmers, and industry consultants during a visit to Norway on May 11-14, 1992.

163. "New Norwegian Salmon Export Company," *Eurofish Report*, June 18, 1992, p. FS/1.

164. The description of some of the new salmon products being offered to consumers was obtained from "ANUGA'91 celebrating in style", *Seafood International*, November 1991, pp.35-36.

165. Erik Hempel's views on the outlook for 1992 were expected to appear in the August 1992 issue of *Seafood International.*

166. Research is being directed at improving the resistance towards furunculosis, coldwater vibriosis, vibriosis, and BKD in Atlantic salmon through selective breeding.

167. The optimalization of protein-fat-carbohydrate ratios in the diet is being studied. Improved nutrition and/or genetic improvements in salmon could result in significantly higher growth rates and reduced feeding costs. These studies are being conducted by Dr. Torbjørn Åsgård, Senior Scientists-Nutrition at the Institute of Aquaculture Research in Sunndalsøra in Norway.

168. These are some of the objectives of the Norske Fiskeoppdretteres Avlsstasjon A/S/ at Kyrksæterøra and at the Akvaforsk, Institutt for akvakulturforskning (the Institute of Aquaculture Research), The Agricultural Research Council of Norway at Sunndalsøra where genetic, nutrition, and other research on salmon smolts is being conducted. This is based on visits to both research facilities on May 12-13, 1992.

SECTION V (Goals)

169. Fiskeridepartementet informer, *Summary of Report Nr. 65 (1986-87) to the Storting on Aquaculture* (English translation).

170. Norske Fiskeoppdretteres Forening, *Aquaculture in Norway*, Trondheim, 1990.

171. *Fish Farming International*, July 1990.

172. Fiskeridepartementet informerer, *Summary of Report Nr. 65, op. cit*, p.9, identified this project and explained its purposes. The report was to provide municipal and state planners with a comprehensive inventory of the coastal zone and waterways in each province.

173. U.S. Embassy, Oslo, October 24, 1990.

Appendix D

Norway

Table 1.--Norway. Atlantic salmon farming, 1970-92.

Year	Hatcheries	Smolt Production	Salmon Farms	Aquatic Area	Salmon Feed	Salmon production By Quantity	Salmon production By Value	
	Number	*Millions*	*Number*	*Cubic Meters*	*Metric Tons*		*Million NOK*	*US$*
1970	NA	NA	5	NA	NA	NA	NA	NA
1971	NA	NA	5	NA	NA	98	NA	NA
1972	NA	NA	5	NA	NA	146	NA	NA
1973	NA	NA	4	NA	NA	171	NA	NA
1974	NA	NA	13	NA	NA	601	NA	NA
1975	NA	NA	45	NA	NA	862	NA	NA
1976	NA	NA	61	NA	NA	1,431	NA	NA
1977	NA	NA	84	NA	NA	2,137	NA	NA
1978	NA	NA	116	NA	NA	3,540	NA	NA
1979	NA	NA	147	NA	NA	4,389	167	43
1980	87	3.8	173	NA	NA	4,312	190	53
1981	84	6.5	215	NA	NA	8,418	272	62
1982	105	7.8	263	NA	NA	10,695	372	57
1983	114	12.5	301	NA	NA	17,298	648	88
1984	128	15.8	354	NA	NA	21,881	846	119
1985	152	18.3	414	NA	NA	29,473	1,293	166
1986	562	27.1	498	NA	NA	44,831	1,624	233
1987	210	43.0	542	NA	NA	46,453	NA	314
1988	692	73.0	643	NA	205,846	78,744	NA	486
1989	642	66.0	696	NA	285,020	111,337	3.6	610
1990	NA	61.0	729	NA	268,531	145,990	NA	795
1991	NA	60.0	NA	NA	234,987	155,000	NA	NA
1992	NA	NA	NA	NA	NA	120,000p	NA	NA

Source: Royal Ministry of Fisheries, Oslo, Norway. *p - Projection.*

Table 2. --Norway. Farmed salmon harvests, by county, 1980-91.

County	Salmon Harvests											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric Tons											
Finnmark	-	-				379	453	710	1,004	1,815	4,952	3,090
Troms.	102	209				1,422	2,443	1,937	2,564	5,165	10,017	8,010
Nordland	755	1,440				5,217	9,028	7,931	11,817	18,662	30,731	28,000
Nord-Trøndelag	338	525				1,987	3,067	2,823	4,475	6,069	10,346	9,530
Sør-Trøndelag	806	1,328				3,667	5,329	3,965	6,283	7,919	12,954	13,680
Møre og Romsdal	682	1,757				6,085	7,510	9,570	14,418	18,986	24,514	23,260
Sogn og Fjordane	287	469				4,174	6,347	8,593	10,732	16,194	18,571	15,700
Hordaland	975	2,386				8,876	12,759	14,786	22,917	31,092	32,213	32,130
Rogaland	167	304				1,861	2,789	4,859	5,952	8,386	11,769	10,010
Sør-og Østlandet	-	-				129	235	556	36	1,145	1,904	2,490
TOTAL	4,112	8,418	0	0	0	33,797	49,960	55,730	80,198	115,433	157,971	145,900

Source: Norske Fiskeførprodusenters Forening, Årsberetning og regnskap 1991, p.8 (for 1989-1991). Norske Fiskeførprodusenters Forening, The Norwegian fish farming industry in harmony with the environment, Trondheim/Tromsø, January 1990, page 18 (for 1985-1987. Note: the original text has errors for Sogn og Fjordane and Hordaland for 1986. These errors have been corrected in this table).

Table 3.--Norway. Atlantic salmon production, by quantity and month, 1980-91.

Year	Production												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	Metric Tons												
1980													0
1981													0
1982													0
1983	1,002	1,141	1,708	1,579	1,506	1,892	1,969	1,300	754	920	1,566	1,679	15,047
1984	1,947	1,869	2,000	2,097	2,041								9,954
1985													0
1986	2,626	2,346	3,480	4,500	3,840	3,842	3,518	3,499	3,695	4,104	4,600	5,618	42,150
1987	4,615	3,527	3,603										11,745
1988													0
1989													0
1990													0
1991													0

Source: Fiskeoppdretternes Salgslag A/L (January 1983-May 1984).

Table 4.--Norway. Feed sales for Atlantic salmon, by quantity and month, 1988-91.

Year	Feed Sales												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	Metric Tons												
1988	7,219	6,659	10,996	6,225	9,377	16,714	25,319	32,865	27,316	27,592	20,361	15,203	205,846
1989	11,694	11,073	12,729	13,061	18,120	27,243	31,273	41,897	36,897	37,089	28,865	15,079	285,020
1990	13,192	11,909	12,732	13,991	19,079	23,552	31,730	37,134	32,210	34,682	25,716	12,604	268,531
1991	15,819	12,736	13,632	14,623	15,664	19,179	29,496	29,529	27,109	28,000	15,400	13,800	234,987

Source: Kilder: Marinet and Norske Fiskefôrprodusenters Forening, Årsberetning og regnskap 1991, p.9.

Table 5.--Norway. Exports of fresh salmon, by quantity and month, 1980-91.

Year	Fresh Exports												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	245	262	296	240	219	362	283	240	279	181	190	300	3,097
1981	251	213	355	557	505	697	593	378	377	434	456	781	5,597
1982	482	517	783	710	745	723	734	464	464	456	727	1,189	7,994
1983	837	848	1,294	1,337	1,111	1,464	1,009	837	683	745	1,197	1,906	13,268
1984	1,190	1,434	1,591	1,675	1,565	1,657	1,309	943	879	1,117	1,902	2,237	17,499
1985													0
1986													0
1987													0
1988													0
1989	5,779	4,959	5,234	5,911	6,190	5,998	5,795	6,049	6,657	8,274	9,267	11,321	81,434
1990	8,470	5,145	7,026	7,483	6,907	7,931	6,569	6,742	7,159	8,568	9,721	11,058	92,779
1991	6,995	4,805	6,135	6,521	7,142	6,831	7,265	6,409	8,959	9,284	8,975	12,417	91,738

Source: Irish Sea Fisheries Board, *Market Information Bulletin - Exports*, March 20, 1985, #5/85 (January 1980-December 1984).

Table 6.--Norway. Exports of frozen salmon, by quantity and month, 1980-91.

Year	Frozen Exports												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	Metric Tons												
1980	10	8	24	37	21	80	284	179	149	220	143	64	1,219
1981	38	48	37	49	46	87	476	374	410	267	254	116	2,202
1982	81	79	81	41	46	83	170	262	321	178	149	81	1,572
1983	12	76	73	123	126	204	392	421	387	359	269	130	2,572
1984	40	114	121	79	177	157	479	390	385	175	286	219	2,622
1985													0
1986													0
1987													0
1988													0
1989	350	429	666	688	572	1,194	1,345	1,500	2,234	2,548	1,501	1,389	14,416
990	911	527	674	2,125	4,426	3,433	2,717	7,505	5,842	5,715	3,007	2,942	39,824
1991	2,391	2,725	2,772	4,480	5,087	4,999	4,050	2,365	1,565	2,529	1,721	709	35,393

Source: Irish Sea Fisheries Board, *Market Information Bulletin - Exports*, March 20, 1985, #5/85 (January 1980-December 1984).

Table 7.--Norway. Exports of smoked salmon, by quantity and month, 1980-91.

Year	Smoked Exports												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
	Metric Tons												
1980	5	4	3	4	7	2	4	2	6	6	7	20	70
1981	3	7	6	6	7	10	7	4	8	13	16	13	100
1982	4	6	7	8	3	9	7	5	5	8	18	16	96
1983	6	7	10	5	9	12	6	13	11	17	26	35	157
1984	12	15	17	21	16	19	15	14	20	31	39	61	280
1985													0
1986													0
1987													0
1988													0
1989													0
1990													0
1991													0

Source: Irish Sea Fisheries Board, *Market Information Bulletin - Exports*, March 20, 1985, #5/85 (January 1980-December 1984).

Table 8. --Norway. Exports of fresh and frozen farmed salmon, by country and quantity, 1980-91.

Country	Fresh and Frozen Exports											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric Tons											
Denmark	625	1,150	1,184	1,957	2,419	3,261	5,627	7,903	14,168	16,316	22,427	36,495
France	784	2,672	2,764	4,298	4,374	5,077	9,549	11,424	18,699	27,420	33,679	30,933
Germany	774	1,558	1,865	2,466	2,625	3,300	4,458	4,715	7,493	10,046	10,204	13,668
Spain	-	-	297	453	697	1,188	1,652	1,993	3,721	7,188	8,990	13,381
Sweden	-	-	673	824	943	1,181	2,119	2,052	2,767	4,255	5,062	9,091
Italy	-	-	-	80	20	50	201	496	1,061	2,989	3,557	6,596
Japan	-	-	34	134	278	417	804	1,553	2,955	5,701	4,657	5,250
Belgium	-	-	372	558	713	960	1,376	1,451	2,136	2,789	2,215	4,301
U.K.	106	582	959	1,381	1,716	1,914	1,600	1,642	2,155	2,936	3,227	2,769
Netherlands	10	56	112	182	291	471	665	868	1,050	3,972	3,686	2,349
Switzerland	0	-	352	504	524	725	901	1,137	1,356	1,567	1,677	2,221
U.S.A.	-	20	717	2,486	4,700	6,716	9,423	8,424	9,941	12,960	10,333	1,295
Other	4,016	1,817	324	221	192	173	0	402	0	849	1,585	3,318
TOTAL	6,315	7,855	9,653	15,544	19,492	25,433	38,375	44,060	67,502	98,988	111,299	131,667

Source: Norske Fiskeförprodusenters Forening, Årsberetning og regnskap 1991, p.9 (for 1989-1991).

Table 9.--Norway. Farmed Atlantic salmon exports, 1970-91.

Year	Exports			Total		
	Fresh	Frozen	Smoked	Quantity	Value	
	Metric Tons				*BIllion NOK*	*US$ million*
1970				NA		NA
1971				995*		NA
1972				1,081*		NA
1973				977*		NA
1974				1,101*		NA
1975				1,335*		NA
1976				1,832*		NA
1977				2,254*		NA
1978				3,531		NA
1979				4,792		43
1980	3,097	1,219	70	4,386		53
1981	5,597	2,202	100	7,899	293	62
1982	7,994	1,572	96	9,662	395	57
1983	13,268	2,572	157	15,997	709	88
1984	17,499	2,622	280	20,401	945	119
1985				0	1,164	166
1986	34,396	4,507	897	39,800	1,693	233
1987	39,179	4,023	938	44,140		314
1988	57,950	10,076	682	68,708		486
1989	81,434**	14,416***		95,850		610
1990	92,779**	39,824***	1,855	134,458		772
1991	91,738**	35,393***	1,763	128,894	48,000	800

Source: U.S. Embassy, Oslo, Norway. * Includes wild salmon exports. ** Includes fresh salmon fillets.

Table 10. --Norway. Exports of farmed salmon, by product form, country, quantity, and value, 1991.

Country	Salmon Exports											
	Fresh			Frozen			Smoked			Total		
	Quantiy	Value		Quantity	Value		Quantity	Value		Quantity	Value	
	Metric tons	*Million NOK*	*$1 million*	*Metric tons*	*Million NOK*	*$1 million*	*Metric tons*	*Million NOK*	*$1 million*	*Metric tons*	*Million NOK*	*$1 million*
Denmark	17,195	579	89	15,651	581	90	-	-	-	32,846	1,160	179
France	24,098	757	117	5,560	187	29	101	12	2	29,750	956	148
Sweden	4,353	167	26	9,133	355	55	288	25	4	13,774	547	85
Spain	12,967	426	66	-	-	-	109	11	2	13,076	437	68
Germany	11,073	421	65	1,537	60	9	174	18	3	12,784	499	77
Italy	5,767	176	27	529	20	3	140	14	2	6,436	210	32
Japan	4,034	168	26	714	26	4	-	-	-	4,748	194	30
Belgium	4,076	148	23	-	-	-	-	-	-	4,076	138	23
U.K.	2,115	79	12	344	9	1	-	-	-	2,459	88	13
Netherlands	2,219	82	13	38	1	-	-	-	-	2,257	83	13
Switzerland	1,808	69	11	176	8	1	107	12	2	2,091	89	14
U.S.A.	577	26	4	-	-	-	381	37	6	958	63	10
ROK	-	-	-	175	9	1	-	-	-	175	9	1
Other	1,278	53	8	1,498	45	7	463	49	8	3,239	147	23
TOTAL	91,560	3,151	487	35,355	1,301	200	1,763	178	29	128,669	4,620	716

Source:

Table 11.--Norway. Exports of smoked farmed salmon, by country and quantity, 1980-91.

Country	Smoked Exports											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric Tons											
France				-		120	131	45				101
U.S.A.				34		332	328	245				381
Germany				61		66	71	63				174
Spain				-		-	-	-				109
Sweden				15		112	100	63				288
Italy				-		55	68	32				140
Switzerland				16		59	71	53				107
Other				31		153	214	181				463
TOTAL	8	0	0	157	0	897	983	682	0	0	0	1,763

Source: Susan Shaw and Mark Gabbot, *An International Study of the Marketing of Farmed Salmon*, Center for Applied Research, Report Nr. 5, 1990, for exports of Norwegian smoked salmon in 1983, 1986, 1987, and 1988.

Table 12. --United States. Imports of fresh salmon from Norway, by quantity and month, 1986-91.

Month	Fresh Imports					
	1986	1987	1988	1989	1990	1991
	Kilograms					
January	697,126	919,784	578,175	1,109,684	791,945	129,704
February	549,070	1,000,182	630,462	964,111	765,648	78,147
March	688,258	1,158,384	716,664	937,279	848,682	20,142
April	1,086,989	646,083	767,097	998,258	995,340	30,253
May	857,084	560,316	814,895	855,671	931,513	23,554
June	731,158	474,620	655,776	895,247	847,050	60,146
July	688,459	400,830	586,033	910,361	848,049	36,021
August	675,845	414,873	625,816	782,271	651,620	29,346
September	582,956	394,429	609,792	937,185	417,114	48,824
October	608,278	430,604	801,414	1,043,539	287,832	52,640
November	943,308	564,843	977,775	1,019,520	230,270	31,128
December	745,036	675,856	1,166,360	1,159,799	188,646	20,001
TOTAL	8,853,567	7,640,804	8,930,259	11,612,925	7,803,709	559,906

Source: U.S. Bureau of Census.

Table 13. --United States. Imports of frozen salmon from Norway, by quantity and month, 1986-91.

Month	Frozen Imports					
	1986	1987	1988	1989	1990	1991
	Kilograms					
January	23,516	16,418	28,025	147,217	101,534	20,585
February	6,541	10,740	17,902	156,365	69,304	15,450
March	14,054	21,300	17,922	174,035	94,608	37,005
April	1,404	12,308	32,778	136,258	198,894	2,856
May	24,741	4,020	30,645	113,081	141,400	53,114
June	19,025	-	3,899	176,057	182,894	29,027
July	19,123	-	-	124,794	70,516	25,432
August	-	-	20,761	78,719	21,570	35,242
September	-	-	22,374	86,923	52,048	10,430
October	-	-	1,602	121,643	70,935	70,221
November	25,367	12,924	1,855	147,023	39,404	42,764
December	2,881	10,756	5,087	126,783	52,048	4,244
TOTAL	136,652	88,466	182,850	1,588,898	1,095,155	346,370

Source: U.S. Census Bureau.

Table 14. --United States. Imports of smoked salmon from Norway, by quantity and month, 1986-91.

Month	Smoked Imports					
	1986	1987	1988	1989	1990	1991
	Kilograms					
January	7,540	8,952	1,893	12,967	20,309	24,083
February	16,345	6,309	5,668	18,461	38,546	45,278
March	9,025	17,016	4,654	22,727	34,722	33,394
April	10,731	13,729	6,928	54,532	44,225	29,094
May	10,135	6,134	5,764	36,050	65,520	38,124
June	25,472	10,804	8,563	40,674	44,634	28,503
July	8,964	4,585	3,453	34,310	46,088	27,524
August	7,524	5,123	7,951	23,668	51,420	30,503
September	8,282	4,731	5,724	41,306	55,760	35,608
October	9,799	11,533	10,481	37,487	40,094	39,889
November	14,618	4,731	10,509	58,384	48,550	35,110
December	13,281	8,443	10,131	82,745	59,914	45,563
TOTAL	141,716	102,090	81,719	463,311	549,782	412,673

Source: U.S. Bureau of the Census.

Table 15. --United States. Imports of fresh, frozen, and smoked salmon from Norway, by quantity and month, 1986-91.

Month	Salmon Imports					
	1986	1987	1988	1989	1990	1991
	Kilograms					
January	728,182	945,154	608,093	1,269,868	913,788	174,372
February	571,956	1,017,231	654,032	1,138,937	873,498	138,875
March	711,337	1,196,700	739,240	1,134,041	978,012	90,541
April	1,099,124	672,120	806,803	1,189,048	1,238,459	62,203
May	891,960	570,470	851,304	1,004,802	1,138,433	114,792
June	775,655	485,424	668,238	1,111,978	1,074,578	117,676
July	716,546	405,415	589,486	1,069,465	964,653	88,977
August	683,369	419,996	654,528	884,658	724,610	95,091
September	591,238	399,160	637,890	1,065,414	524,922	94,862
October	618,077	442,137	813,497	1,202,669	398,861	162,750
November	983,293	582,498	990,139	1,224,927	318,224	109,002
December	761,198	695,055	1,181,578	1,369,327	300,608	69,808
TOTAL	9,131,935	7,831,360	9,194,828	13,665,134	9,448,646	1,318,949

Source: U.S. Bureau of the Census.

Table 16 --United States. Imports of fresh salmon from Norway, by value and month, 1982-91.

Month	Fresh Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
					US$1.00					
January	154,165	1,273,498	2,249,165	3,310,057	5,592,696	5,565,487	5,055,252	7,544,339	4,498,127	831,022
February	213,689	1,890,674	2,211,160	3,889,965	4,510,031	6,175,596	4,998,077	6,297,301	4,557,749	500,752
March	568,818	1,235,578	3,786,504	5,594,625	5,392,806	7,329,747	5,623,153	5,948,489	5,217,915	113,133
April	312,867	1,999,602	3,873,123	3,873,667	8,106,599	4,767,197	5,977,426	6,101,266	6,247,334	187,469
May	386,291	1,154,347	3,431,226	4,787,126	6,476,739	4,529,836	6,480,657	5,273,693	5,945,867	104,655
June	151,349	966,867	2,317,701	3,303,715	4,890,759	4,076,234	5,386,045	5,190,220	5,432,178	252,091
July	226,444	756,474	2,467,078	3,695,652	4,242,372	3,234,864	4,923,428	4,966,562	5,262,813	160,921
August	66,955	638,433	1,175,728	2,615,613	3,968,774	3,335,781	5,028,941	4,310,156	4,171,668	128,713
September	111,761	443,105	1,273,938	2,632,789	3,621,601	3,361,613	4,726,116	5,251,498	2,879,668	224,976
October	305,950	628,441	1,108,272	3,306,506	4,067,553	3,731,054	6,161,719	5,810,622	1,933,122	273,838
November	415,135	877,468	1,793,341	3,883,081	6,470,961	4,782,178	6,792,529	5,413,045	1,517,484	142,941
December	657,233	916,470	2,656,364	5,382,667	4,735,181	5,671,836	8,087,143	6,143,718	1,252,442	88,372
TOTAL	3,570,657	12,780,957	28,343,600	46,275,463	62,076,073	56,561,423	69,240,486	68,250,909	48,916,367	3,008,883

Source: U.S. Bureau of the Census.

Table 17. --United States. Imports of frozen salmon from Norway, by value and month, 1986-91.

Month	Frozen Imports					
	1986	1987	1988	1989	1990	1991
	US$1.00					
January	215,135	102,524	222,027	1,015,050	651,637	186,255
February	50,673	70,850	159,871	1,077,545	454,707	131,107
March	104,458	180,689	114,714	1,171,385	625,074	296,106
April	10,527	93,042	285,996	874,721	1,247,258	26,834
May	182,587	42,179	253,978	712,153	926,196	549,607
June	129,674	-	67,111	1,028,240	1,186,207	272,699
July	126,442	-	-	679,696	501,157	252,478
August	-	-	187,832	425,257	210,965	289,299
September	-	-	219,851	516,344	399,042	110,822
October	-	-	16,489	702,197	565,804	508,644
November	184,114	62,260	16,123	850,728	333,666	325,652
December	25,423	94,976	35,008	691,927	482,251	45,933
TOTAL	1,029,033	646,520	1,579,000	9,745,243	7,583,964	2,995,436

Source: U.S. Bureau of the Census.

Table 18. --United States. Imports of smoked salmon from Norway, by value and month, 1986-91.

Month	Smoked Imports					
	1986	1987	1988	1989	1990	1991
	US$1.00					
January	105,339	123,684	29,793	227,746	315,863	391,098
February	243,730	90,066	99,881	274,836	566,615	823,744
March	134,228	223,056	74,511	344,132	529,922	562,005
April	138,124	178,648	134,557	791,298	672,373	445,052
May	141,872	81,279	107,206	584,773	1,010,886	682,450
June	371,091	172,586	159,231	657,299	684,253	424,531
July	123,509	70,150	66,199	470,017	498,781	380,862
August	104,721	77,094	140,900	371,209	705,353	464,025
September	115,328	72,741	103,274	634,962	951,351	535,273
October	124,330	167,342	170,774	507,216	668,585	594,293
November	174,243	81,121	180,593	868,027	783,144	558,217
December	174,465	145,310	180,004	1,151,928	1,047,534	756,205
TOTAL	1,950,980	1,483,077	1,446,923	6,883,443	8,434,660	6,617,755

Source: U.S. Bureau of the Census.

Table 19. --United States. Imports of fresh, frozen, and smoked salmon from Norway, by value and month, 1986-91.

Month	Salmon Imports					
	1986	1987	1988	1989	1990	1991
	US$1.00					
January	5,913,170	5,791,695	5,307,072	8,787,135	5,465,627	1,408,375
February	4,804,434	6,336,512	5,257,829	7,649,682	5,579,071	1,455,603
March	5,631,492	7,733,492	5,812,378	7,464,006	6,372,911	971,244
April	8,255,250	5,038,887	6,397,979	7,767,285	8,166,965	659,355
May	6,801,198	4,653,294	6,841,841	6,570,619	7,882,949	1,336,712
June	5,391,524	4,248,820	5,612,387	6,875,759	7,302,638	949,321
July	4,492,323	3,305,014	4,989,627	6,116,275	6,262,751	794,261
August	4,073,495	3,412,875	5,357,673	5,106,622	5,087,986	882,037
September	3,736,929	3,434,354	5,049,241	6,402,804	4,230,061	871,071
October	4,191,883	3,898,396	6,348,982	7,020,035	3,167,511	1,376,775
November	6,829,318	4,925,559	6,989,245	7,131,800	2,634,294	1,026,810
December	4,935,069	5,912,122	8,302,155	7,987,573	2,782,227	890,510
TOTAL	65,056,085	58,691,020	72,266,409	84,879,595	64,934,991	12,622,074

Source: U.S. Bureau of the Census.

SPAIN

Spain has a small salmon aquaculture industry which harvests Atlantic and Pacific salmon. However, given the increasing scarcity of suitable sites for aquaculture, and the many high-value species which Spain successfully cultures, it is unlikely that salmon culture will expand much at the expense of other cultured species. Only Galicia harvests commercially significant amounts of farmed salmon.

CONTENTS

I. GENERAL

Spanish salmon culture began using Pacific salmon species during the early 1980s. Spanish salmon farmers began culturing Atlantic salmon during 1988. Spain has very warm coastal waters. Because salmon prefer colder waters, there has been high mortality reported by Spanish salmon farmers during the summer when water temperatures rise.[1] This problem has also plagued salmon farmers in France. Norwegian investors (who provided both capital and technical assistance to begin salmon farming operations in Spain) express confidence that the technical problems of warm water culture can be overcome, however.

Because of the small scale of Spanish salmon culture, it has a minimum impact on Spain's overall economy. The Spanish market for salmon has increased significantly during the past decade. This expansion is directly attributed to the promotional efforts of Norwegian salmon exporters who have developed an important market for their products in Spain. To some degree, therefore, salmon culture can provide only limited import substitution for the Spanish economy. Salmon culture in Spain is unlikely to expand to any commercially important level. Thus, the impact of salmon farming on imports should remain small.

II. HARVESTS

Spanish salmon farmers import smolt for their ongrowing sites. Spanish harvests of farmed salmon were only 150 t of Pacific salmon annually from 1985 through 1989.[2] That only represents between 30,000 and 50,000 market-sized, individual salmon.[3] Spanish farmers expanded 1990 production to 355 tons, which included 205 t of Atlantic salmon and 150 t of Pacific salmon. Harvests expanded again during 1991 to 553 tons, which represents a 36 percent increase in production during the 1990-1991 season.[4] As during 1990, however, all of the increased harvest came from increased production of Atlantic salmon: Spanish salmon farmers harvested 403 t of Atlantic salmon during 1991 while Pacific salmon harvests remained static at 150 tons.

III. COMPANIES

In all, there are 5 Spanish companies involved in salmon culture, all based in Galicia.[5] The largest is **Marcultura S.A.**, which continued to operate under full capacity and expand at least through 1989. Marcultura sited its farm in Santiago de Compostela. The second largest producer is **Esteiro Seafarm, S.A.**, which began commercial sales during 1989. This company is located at La Coruña. **Salmon Atlantico, S.A.**, and **Norafish S.A.** also operate out of La Coruña.[6] The fifth company, **Eurosalmon S.A.**, began operations after 1989.[7]

IV. EXPORTS

There are no reported exports of Spanish-grown farmed salmon and no exports are anticipated.

V. OUTLOOK

The outlook for future expansion of salmon farming in Spain is limited. Spain is a leading world producer of many aquatic fish and shellfish, and it is likely that they will continue to expand their area of expertise. Rather than pursue salmon culture at the expense of developing more promising species, Spain is likely to rely on imports to meet salmon demand.

In addition to these practical factors, the government's 1991-1992 multiannual guidance program for aquaculture places a ceiling on salmon culture production. According to industry sources, the program ceiling is dictated by market conditions in Spain.[8]

SOURCES

Barnabé, Gilbert. *Aquaculture*, Volume 1, Ellis Horwood Limited, West Sussex, England, 1990, p. 78.

J.L. Miranda, Counselor for Agriculture, Fisheries and Food, Embassy of Spain. Personal communications and fax message dated July 23, 1992.

U.S. Consulate General, Barcelona, various reports.

Ministerio de Agricultura, Pesca Y Alimentacion, Secretaria General De Pesca Maritima, Embassy of Spain, Washington, D.C. Facsimile transmission dated July 29, 1992.

Monserrat Canela, Foreign Service National, U.S. Consulate General, Barcelona, Spain. Personal communications, August 3, 1992.

SPANISH SALMON FARMS[9]

ESTEIRO SEA FARM, S.A.
C/Juana de vega, 35, 3°
15004 Couso Ribeiera (LA CORUÑA)
SPAIN
Tel: 34-81-211300

EUROSALMON, S.A.
Fruela, 14, 7°
33007 OVIEDO, SPAIN
Tel: 34-85-225711

MARCULTURA, S.A[10].
Las Cancelas, 59
15704 Santiago, SPAIN
Tel: 34-81-584621

NORAFISH, S.A.
Porto Meiras-Valdoviña
15552 LA CORUÑA, SPAIN
Tel: 34-81-276300
Fax: 34-81-257650

SALMON ATLANTICO DE GALICIA (SAGAL)
Saro Villano, Camariñas
15123 LA CORUÑA, SPAIN
Tel: 34-81-736466
Fax: 34-81-736220

ENDNOTES

1. The *optimum* temperature for growing Atlantic salmon is 15 Degrees Celsius and the *maximum* temperature is 28 Degrees Celsius. No information was provided on the water temperatures of the Spanish salmon farms during the summer months. Gilbert Barnabé, *Aquaculture*, Volume 1, Ellis Horwood Limited, West Sussex, England, 1990, p. 78. It should be noted that salmon generally grow rapidly in the summer months when water temperatures rise. However, there is a big difference between the "warm" summer waters off Northern Norway or Iceland and the water temperatures around Spain during the summer months.

2. U.S. Consulate General, Barcelona, December 7, 1989.

3. That is, assuming that fish were grown to the usual market size of 3-5 kilograms apiece.

4. Ministerio de Agricultura, Pesca Y Alimentacion, Secretaria General de Pesca Maritima, sent via fax message by the Embassy of Spain, Washington D.C. on July 29, 1992. The data does not, unfortunately, provides only a total harvest and does not show the harvest by Pacific or Atlantic salmon species.

5. U.S. Consulate General, Barcelona, December 7, 1989.

6. U.S. Consulate General, Barcelona, December 7, 1989.

7. Embassy of Spain, Washington D.C., July 29, 1992.

8. Embassy of Spain, Washington D. C., July 29, 1992.

9. This listing was provided by Mr. J.L. Miranda, Counselor for Agriculture, Fisheries and Food at the Embassy of Spain in Washington, D.C. on July 23, 1992.

10. Marcultura operates two facilities, one in Esteiro-Muros and one is Sismundi-Cariño, both in La Coruña. The company also grows molluscs and turbot.

Chapter IX
Western Europe

SWEDEN

Sweden is ideally suited for salmon farming. The Swedish coastline is about 2,862 kilometers in length and is dotted by many protected bays, coves, and islands. The country has many rivers and lakes, and inland waters account for nearly seven times the arable land resources of the country. However, Sweden imports most of its salmon and has only a small salmon farming program. Swedish salmon culture is divided into stocking programs and farming for human consumption. Sweden maintains a large Atlantic salmon (*Salmo salar*) restocking program in its rivers and waterways. Swedish salmon farming falls far behind that of its Nordic neighbors; farmers harvested only 700 metric tons of farmed Atlantic salmon in 1991.[1] Sweden continues to import salmon to meet consumer demand, and Norway made a major effort to ship frozen salmon to Sweden in 1991 as part of their program to reduce excess stocks of salmon from traditional markets. The outlook for Swedish salmon production is for only modest harvests in the future.

CONTENTS

I. GENERAL

Swedish salmon aquaculture began in the 1970s, but was exclusively for scientific research or restocking. Commercial salmon farming began in 1982, when 10 metric tons (t) of Atlantic salmon were harvested.[2] According to the Swedish government, salmon aquaculture in Sweden may include small family run operations, which produce either smolt or food fish, but which do not enter the commercial statistics.[3] Despite close proximity to Norway, the practice of raising salmon has never become a major commercial venture in Sweden.

Swedish consumers prefer rainbow trout, which Swedish fish farmers are growing in significant quantities. In 1989, Swedish fish farmers harvested slightly over 6,500 t of rainbow trout as compared to over 700 t of salmon. Fish farmers also grew just under 200 t of European eel, 100 t of Arctic char, and 200 t of blue mussels. The value of Sweden's total

aquaculture harvest was $27 million in 1989 compared with only $7 million in 1984.[4]

II. HARVESTS

A. Smolts

Sweden faces a problem common to many European nations (particularly Finland and Ireland). Post World War II reconstruction of hydroelectic dams blocked many of the nation's most productive salmon spawning rivers. Citizen concern over loss of these salmon resources led the government to enact legislation requiring power companies to restock rivers that were blocked by massive dams. Hydroelectric companies currently operate at least 20 hatcheries to raise smolts for restocking Sweden's rivers.

B. Salmon

Swedish government sources report that most of the nation's salmon culture occurs on a very small scale; most facilities consist of a natural, uncovered pond. There were 17 salmon farms operating in Sweden, largely on the Northern Baltic Sea, in 1990. Salmon farming began in 1982, when 10 t of Atlantic salmon were harvested by a small farm. Swedish salmon farmers did not commercially produce more than 100 t of salmon per year until 1986.[5] Swedish salmon farmers put their largest crop of salmon to date in pens during 1988, following the record profits of 1987, and harvests increased rapidly, exceeding 1,100 t in 1990. The decline in world salmon prices that began in 1989 sounded an alarm in Sweden (unlike most other countries) and Swedish farmers decreased their stocking levels. This led salmon harvests to decline to slightly over 700 t in 1991 (table 1).

III. EXPORTS

Though Sweden does not produce much cultured salmon, Swedish aquaculture firms are very active in the market for aquaculture products and processing. Farmocean AB, for example, produces offshore farming cages for large scale salmon culture. EWOS, a member of the large Alfa Laval aquaculture group, produces fish feed for aquaculture. These ancillary aquacultural products constitute the bulk of Sweden's farmed salmon-based exports.

Table 1.--Swedish farmed salmon culture, 1983-1991.

Year	Salmon harvest
	Metric tons
1982	10
1983	27
1984	59
1985	81
1986	160
1987	224
1988	363
1989	771
1990	1,114
1991	732

Source: Statistiska meddelanden and U.S. Embassy, Stockholm.

IV. OUTLOOK

Swedish fishermen catch about 1,000 t of salmon annually, fish farmers harvest around 1,000 t of salmon, and importers buy around 5,000 t of salmon (including Atlantic salmon) annually.[6] Since Sweden exports little if any of its domestic salmon harvest, it would appear that the total market for farmed salmon is about 7,000 tons.[7] It is not known if there are any plans to expand Sweden's salmon farming industry to supply the local market, or if there is any interest in expanding harvests to meet world demand. In view of the generally poor prices for farmed salmon in the past few years, it appears that the decision to reduce output was a wise one. Few Swedish salmon farms appear to have suffered losses in recent years, and could expand production quickly if market prices increase. However, the outlook for Swedish salmon production appears limited for the immediate future.

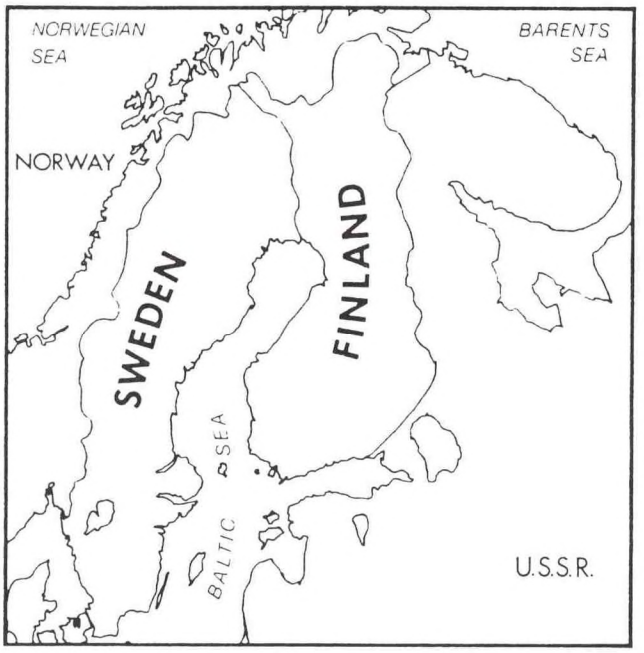
SOURCES

"Fisheries in Sweden," *Fact Sheets on Sweden,* The Swedish Insitute, Sweden, May 1973.

Stastiska meddelanden, *Fiske 1989 - en översikt*, Statstiska Centralbyran (Stockholm: 1990).

"The Mass Production of Salmon in New Type of Offshore Farms," The Swedish Interntional Press Bureau, August 25, 1985.

U.S. Embassy, Stockholm, various reports.



ENDNOTES

1. U.S. Embassy, Stockholm, May 6, 1992.

2. U.S. Embassy, Stockholm, May 12, 1987.

3. U.S. Embassy, Stockholm, May 12, 1987.

4. "Sweden's Fishing Industry, 1989,"U.S. Embassy, Stockholm, Sweden, April 11, 1991.

5. This figure is live, round weight. Swedish fish farmers produced 136 t of cultured salmon during 1986 if based on "slaughter weight".

6. U.S. Embassy, Stockholm, May 6, 1992.

7. Information on Sweden's sports catch of wild Atlantic salmon are not available, but would also contribute to the total market for salmon in Sweden. Recreational fishing is quite popular in Sweden and fishing for salmon is certain to account for reasonable quantities of that fish.

TURKEY

A Turkish salmon farm, called *Aquafarm*, has started raising Atlantic salmon using Norwegian smolts and technical expertise in the Black Sea. According to the Managing Director of Aquafarm, E. I. Irdem, the facility is equipped with the most modern salmon raising equipment, including: automatic feeders, infrared security systems, environmental controls, and system-control devices. Mr. Irdem claims that European aquacultural engineers will assist the company in preparing a high quality salmon product and that the process will include controls to assure the highest quality smolts and feed. Mr. Irdem also reports that the salmon will undergo strict hygiene and quality control testing, conducted by a team of European biologists and pathologists, before being marketed. In Irdem's opinion, Turkey has a clear chance to compete with European and American salmon farms because of the mild climate; the variations in temperatures during the year are extremely narrow. Mr. Irdem also points to the nutrient-rich waters of the Black Sea as another key factor that should bring the company success. Because of these factors, he claims that it is possible to raise first-class Atlantic salmon weighing about 4 kg in a little more than 10 months after smoltification. That is half as long as it takes to raise salmon in the colder northern European waters.[1]

ENDNOTES

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1. The claims made by Mr. Irdem appear optimistic. It will be interesting to review the status of the farm after a year or two of operating experience. The ability of the farm to raise 4-kilogram salmon after only 10 months for example, represents a significant breakthrough in salmon culture. Salmon farmers in Spain have reported massive mortalities associated with warm weather; it is possible that water temperatures in the Black Sea won't reach similar levels. No information was provided about water temperatures in the article. "TÜRKEI: Lachszucht im Schwarzen Meer," *Informationen über die Fischwirtschaft des Auslandes*, Herausgegeben von der Bundesforschungsanstalt für Fischerei, Hamburg, Heft 2, 1992, pp.46-47. The article quotes *Fish Farming International*, January 19, 1992 as its source.

Chapter IX
Western Europe

UNITED KINGDOM
(Scotland)

Scottish farmers harvested a record 40,600 metric tons in 1991, making Scotland the second largest producer of Atlantic salmon (*Salmo salar*) in the world. The United Kingdom is Scotland's most important market. Only the United Kingdom, Japan, and the United States produce farmed salmon primarily for domestic consumption. UK salmon producers did, however, export over 17,000 tons of salmon, mostly to France, the United States, Japan, and other EC countries. The UK also imported over 4,500 tons of salmon leaving a balance of about 28,800 tons for use by smokers and for sale to UK consumers. Salmon is now the third most popular seafood in the UK after cod and haddock. The outlook for 1992 is similar to 1991.

CONTENTS

I. GENERAL

A. Historic

Scottish[1] biologists have been attempting to improve wild salmon runs for over 150 years. The first efforts to incubate and hatch salmon eggs took place in 1838. Biologists established many hatcheries on rivers where obstructions (such as waterfalls) blocked access to good spawning ground for salmon returning from the sea. These hatcheries enabled biologists to release eggs and fry above the obstructions, expanding spawning grounds. By the late 1880s there were 18 hatcheries operating in Scotland.[2] Later Scottish biologists utilized the knowledge and data gained from these early hatchery efforts when they began experimentally raising smolts in the early 1960s. Researchers in the United Kingdom (UK) quickly developed the technology for feeding salmonids in salt water pens, which allowed salmon farming to develop as a commercial venture. The first commercial salmon farms began near Aberdeen and at Loch Ailort in Inverness-shire in 1969.

B. Location

Britain's salmon culture industry is located along the western and northern coast of Scotland (figure 1). The region is sparsely populated with many coastal inlets or islands suitable for raising salmon.

The Scottish **Highlands** are known for their windswept moors, old castles, rocky coastline, and picturesque lochs. Many salmon farms have been established in these areas in recent years. Salmon farmers in the Scottish highlands accounted for almost 37 percent of Scottish salmon production during 1991.[3] The Highlands produced the largest fish in all categories of salmon production, suggesting favorable growing conditions in this region.

The **Western Isles** include the Inner and Outer Hebrides. About 30,000 people inhabit the Western Isles and unemployment is high. The islands are well suited for salmon farming with plenty of freshwater lochs. McConnel Salmon Ltd. began salmon farming in the Isles in 1975. The Isles account for about 14 percent of Scottish farmed salmon harvests (5,622 metric tons (t) out of the total 40,593 t salmon harvested in 1991). The Integrated Development Plan (IDP) provided financial assistance to the islanders to help start salmon farming. By 1987, some $7 million in IDP funds had assisted 40 salmon farms in beginning operations. In addition, 12 smolt farms had been started and were able to produce 600,000 smolts by 1967.[4] Several independent salmon farmers established a marketing association, called Hebrides Harvest, in 1989 consisting of 8 members. The group sells about 700 t annually.[5]

Salmon farmers also operate sites in the **Orkney Islands**, located just off the northern coast of Scotland. There are 5 smolt hatcheries and 14 salmon farms operating on the Orkneys as of January 1992. The Orkney Islands have fast moving tidal waters that sweep the sea pens with a constant flow of clean water. This forces the fish to swim constantly, yielding a firm fish with a low fat content. Orkney-reared salmon have a 9.4 to 9.6 percent fat content. The farms in the Orkneys are small and harvest between 40 t and 400 t annually, which is a small quantity in comparison with large salmon farms Total production is expected to reach 1,000 t in 1992.[6] In 1989, the salmon farmers established the Orkney Salmon Company to market their products on a year-round basis. Nearly 60 percent of the Orkney Salmon Company's product is sold on the UK market and the rest is exported, mostly to northern Europe. The consortium deals primarily with caterers and hotel suppliers.[7] The Scottish Salmon Growers Association represents Highland, Western Isles, and Orkney producers.

The **Shetland Islands** are located north of Scotland in the North Sea. The Shetlands include hundreds of uninhabited islands and 18 populated islands. Salmon farming has expanded rapidly from 50 t in 1984 to 10,600 t in 1991. The Shetlands accounted for about 26 percent of the UK's total salmon production in 1991.[8] Salmon farmers in the Shetlands were initially hindered by the lack of smolts; the islands are small and barren and there is a scarcity of freshwater to grow smolts. Thus the Shetland industry began using Norwegian smolts carried to the islands in well boats (carriers with live tanks). A Norwegian joint venture operation, **Shetland Salmon Producers Ltd.**, began on the island of Skeld in 1982 and is now the largest salmon grower in the islands.[9] **Shetland Norse Fish Farm**[10] is another of the largest fish farms in the islands. The **Shetland Seafood Quality Company** was established in the mid-1980s to insure a quality image for Shetland salmon products. The shareholders in the company include the Shetland Salmon Farmers' Association, the Shetland Farmers' Association, and

the Shetland Fish Processors' Association.[11] There were 52 salmon farms operating in the Shetlands by 1991.[12] The industry transports its salmon to the Scottish mainland by ferry, and then trucks the salmon to Aberdeen and Glasgow for air shipment to distant markets. The **Shetland Salmon Farmers' Association** (SSFA) assists Shetland salmon farmers in their marketing efforts.[13] The Scottish Salmon Board promotes the marketing for the Scottish industry including some Shetland farmers.

C. Methods

Scottish salmon farmers employ two salmon farming methods. The first uses offshore cages anchored at sea. The other method uses on-shore tank culture.

1. Off-shore

Most of the industry uses off-shore salmon pens averaging 12 meters by 12 meters in size. Several pens are clustered together, forming a single site. These sites include a platform that is used to store feed and supplies. The platform usually has a wooden walk leading to the various pens, which allows the farm staff to inspect the pens, feed the fish, and make repairs to the facility. These pens are generally built to withstand rough weather, but severe winter weather can result in fish escapes.

2. On-shore

On-shore facilities use large tanks to grow salmon (typically used in raising smolts) on land. On-shore systems are considerably more expensive to build and operate than off-shore pens, but the system allows for minimal loss due to bad weather, and it is easier to control

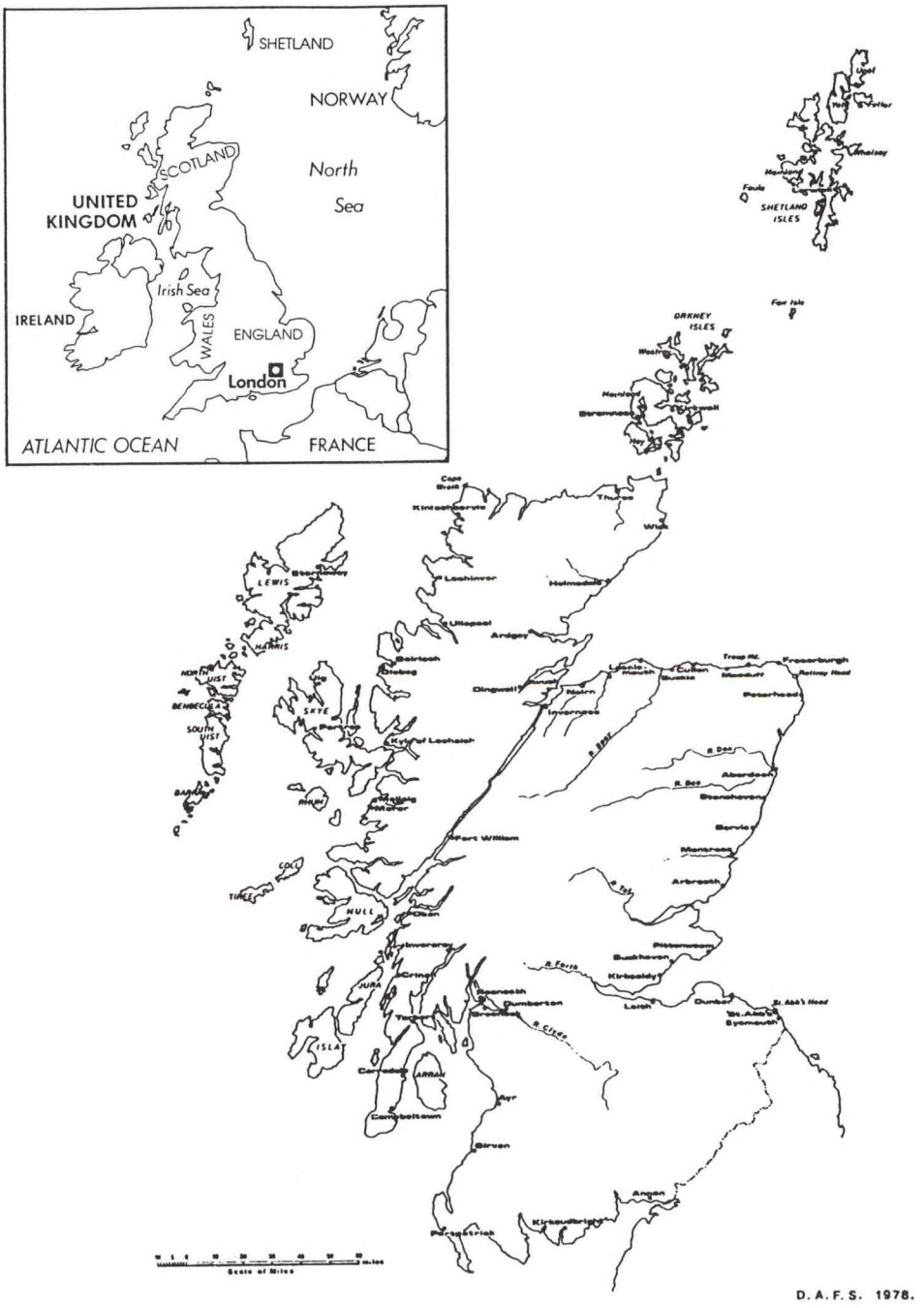

Figure 1.--Map of Scotland.

diseases and feeding at on-shore facilities. It is also possible to carefully control wastes in a well-designed on-shore facility.

D. Economics

Salmon aquaculture has become an important industry in the Scottish economy. Salmon culture provides virtually the only employment opportunities in some isolated, rural areas of Scotland (a trend accentuated by the decreasing demand for Scottish textiles). In 1988 John MacKay, Minister of Education, Agriculture and Fisheries, reported that Scotland's production of farmed salmon was expected to exceed $160 million -- "almost half the value of the Scottish sea fisheries catch in 1987."[14] By 1990, salmon farming contributed approximately $300 million to the Scottish economy. Salmon farming in 1991 employed 6,300 people directly indirectly in rural Highlands and Islands communities.[15] The industry is thus providing jobs in some of the most remote and economically disadvantaged communities in the United Kingdom. Furthermore, the value of Scottish farmed salmon harvests in 1990 exceeded the value of both lamb and beef production combined in the Highlands. Because of its favorable economic impact, Scottish aquaculture received $37 million in financial assistance from both the UK and the European Community (EC).

E. Processing

Scottish salmon is available in fresh, frozen, and smoked form. The traditional styles are fresh and smoked, but processors are developing frozen entrees to meet the needs of large supermarket chains. Fresh salmon is still considered a premium product, and Scottish salmon's reputation for freshness is still an important aspect of farmers' marketing strategy. Scotland's best known salmon product, however, is the famous smoked Scottish salmon. The Scots have been smoking salmon for generations (initially wild salmon, but now mostly farmed) and they produce an excellent product that commands premium prices.

F. Role of government[16]

There are several agencies involved in regulating or supporting Scottish salmon culture. In recent years government agencies have had to balance the needs of fish farmers against other interests, such as the tourist industry and environmental concerns, which have different priorities for land use.[17]

1. Government agencies

Administrative control of Scottish salmon farming is extremely complex. Different aspects of Scottish salmon farming fall under the jurisdiction of several governmental bodies whose authorities appear to overlap. The Scottish Office, headed by a Secretary of State (who is also a member of the UK Cabinet), is responsible for the administration of salmon farming in Scotland. The Scottish Development Department (SDD) is responsible for planning of salmon farming, including the allocation of sites. The Department of Agriculture and Fisheries for Scotland (DAFS), on the other hand, is responsible for the daily operations of salmon farms in Scotland. The DAFS, for example, is responsible for registering all salmon farms, administering disease legislation, research and development, and working with the EC on questions of aquaculture including grant programs. Other governmental agencies dealing directly or indirectly with salmon farming include: River Purification Boards, local planning authorities, Crown Estate Commissioners, the Highlands and Islands Enterprise, industry bodies, and the Scottish Development Agency.

2. Seabed leasing

Off-shore sites fall under a distinct structure in addition to the governmental agencies which control all Scottish salmon farming. The Crown Estate Commissioners have absolute control of the seabed up to 3 miles from the coast around the British Isles. Any prospective salmon farmer is required to obtain the permission of the Crown before establishing a farm site. The Crown requires environmental studies and input from concerned citizens as part of its approval process. The process is difficult and many applications have been denied in recent years. The Crown Commissioners, however, maintained very low rents for fish-farming seabed leases, which helped the industry get started. In 1987, the Crown Estate increased leases for salmon farms to about $90 per ton of salmon, and to about $80 for those harvesting less than 50 t per year.

3. Grants and aid

EC Aquaculture Development Programs and the Highlands and Islands Enterprise (HIE) provide funding for salmon farming. Approximately $40 million in public funds have been allocated to the UK's salmon-farm development. Between 1975 and 1984, for example, the HIE awarded grants worth $12.6 million to fish farms and gave loans worth

$5.2 million to fish farmers (including trout and shellfish farms).[18] The EC provides grants under the European Agricultural Guidance and Guarantee Fund (known by its French initials FEOGA). FEOGA will provide up to 25 percent of the capital costs of a qualified project. The EC requires the local government to provide at least 5 percent in matching funds, which is permitted under the UK Marine Fish Farming (Financial Assistance) Scheme of 1984.[19] Finally, grants were provided in underdeveloped areas of Scotland under the Industrial Development Act of 1982, or under the Integrated Development Program for the Western Isles.[20]

4. Disease control

The Diseases of Fish Acts of 1937 and 1983 serve as the principal legislation on disease control in Scotland. DAFS administers both laws (including amendments and other minor legislation). This disease control legislation includes provisions prohibiting live salmonid importation into the UK. The DAFS also conducts research into salmon diseases and provides information about salmon husbandry.

II. PROBLEMS OF CULTURE

A. Disease

Scottish farmed salmon have suffered outbreaks of several diseases common to their species. Furunculosis and lice infestations were the major cause of smolt losses from the 1989 class. Scotland's salmon farmers also suffered heavy losses due to furunculosis and sea lice during the 1990 and 1991 seasons, but farmers now have these problems under control.

The most effective method of controlling furunculosis in sea sites is allowing cages to remain fallow for a year. This DAFS-recommended practice deprives the parasite which causes furunculosis of a host, thus ridding sites of infestation. Fallowing is now more widely practiced in Scotland, and compliance with this recommendation is increasing.[21]

Salmon lice infestations require other treatment. If infected salmon are able to eat, they can be treated with medicated feedstuffs. However, because European consumers are very critical of chemical residues in foods, salmon farmers now avoid chemical treatment as much as possible. Salmon can be chemically "dipped" to control lice, but this stresses the fish. Salmon farmers are now widely using newer "natural" methods of salmon delousing. Farmers have introduced wrasse (a species of fish which eats salmon lice) as a natural delousing agent in their cages. Shetland salmon farmers have also discovered that cut onions hung in salmon nets repel sea lice. These highly cost-effective treatments are now commonly employed.[22]

B. Weather

From time to time, harsh winter storms batter exposed sea cage sites along the Scottish coastline. Because of the benefits of good water "change out," including effective waste removal and increased oxygenization, Scottish salmon farmers have chosen off-shore sites with strong water flow. These sites, however, are also generally more weather-exposed. Scottish producers suffered some damage from a heavy winter storm during early 1992. Scottish losses were comparatively light, however.[23]

C. Predators

Because salmon have many natural predators, salmon farmers employ anti-predation nets. These usually encircle the salmon cage at a distance of a few meters. Anti-predation nets thus keep predators from reaching through the cage and killing or injuring the farmed salmon. Unfortunately, predators become entangled in the anti-predation nets and drown. In other cases, predators simply chew through the nets to reach the salmon.

1. Seals

Scottish salmon farmers have a particular problem with seal predation. Seal predation leads to expensive repairs and loss of valuable stock. In some cases, seal damage to salmon nets has resulted in larger numbers of farmed salmon escaping. Seals are one of the chief problems facing salmon growers in the Shetlands.[24] In addition to seals which are injured or killed in their predation attempts, some are killed each year by farmers. The UK Marine Conservation Society claimed that 1,000 seals were shot or trapped in salmon nets in Scotland in 1986.[25] Later reports suggest that 2,500 to 5,000 seals are killed each year.[26] The industry reports, however, that approximately 350 seals are shot annually.[27] Seal mortality from salmon farming angers some environmental groups, who maintain that the seals are

behaving normally and that salmon culture is the offensive activity.[28] To alleviate these problems, salmon farming companies have developed many different types of "seal scarers." These scarers are often alarms or sonic devices which are designed to be repellent to the marine mammals.

2. Sea birds

In addition to predation from the water, farmed salmon also face predation from sea birds. Though sea birds occasionally dive at salmon nets from below, they more often attempt to reach the fish from above. For this reason, salmon farmers also suspend a net over their cages to keep sea birds from their stock.

3. Mink, otters, and man

Scottish salmon farmers have also reported mink and otters eating their salmon, and environmental groups also allege that salmon farmers destroy these animals.[29] Unfortunately, human poachers and vandals also do considerable damage to isolated facilities.[30]

D. Use of chemicals

Salmon farming impacts the environment through waste production, medications and other chemicals which farmers introduce into pens, and excess feed. Some believe that the negative impacts of salmon farming outweigh the economic benefits it provides. Others insist that fishing wild salmon stocks to extinction would be more harmful, and that salmon farming fills the gap in demand which wild stocks can no longer supply.

Regarding chemical waste products of salmon culture, many are concerned not only about possible environmental damage but also about consuming chemically treated salmon. Salmon are often given feed which contains natural pigments, growth stimulants, delousing agents, antibiotics, or other chemicals.[31]

Some of the waste products of salmon culture have received great notoriety. One such example was the use of Nuvan (later renamed Aquaguard). The active ingredient of Nuvan, a chemical delousing agent called dichlorvos, was found to be highly toxic to molluscs and other crustaceans within a 25 meter radius of the salmon cages. Nuvan was used extensively in Scotland, until research indicated that Nuvan also killed oysters, mussels, and other shellfish and crustaceans near salmon farms. Shellfish farms are thus located at least 500 meters away from salmon cages. Research at the University of Aberdeen suggested that Nuvan caused cataracts and blindness in wild salmon exposed to farm run-offs of the chemical.[32] This theory, however, has been discredited. UK Authorities began attempts to ban the use Nuvan in 1989, but allowed licensed use of the product through 1992 and 1993.[33]

III. HARVESTS

A. Smolts

Salmon are reared from the egg through the smolt stage in land-based fiberglass tanks. The tanks are supplied with both fresh water, and some fish are reared at an intermediate salinity when smolting. After one or two years smolt (termed "1S" and "2S" respectively) have reached a weight of about 30-50 grams. At this point, the salmon undergo the natural physiological process of "smoltification" and become adapted for life in seawater. The smolts are then transferred to sea cages for ongrowing. After transfer, growth is rapid: salmon reach a market size of 3-7 kg in about 2 years.[34]

Scottish smolt producers supply the domestic market and previously provided smolts for a small export market. During 1985, a Scottish shipment of 5 million smolts with furunculosis damaged Scotland's reputation and export market in Norway. At the present time, no export market exists because of EC health regulations. Scotland's 38 broodstock sites produced over 7 million smolts in 1986. Smolt production doubled during 1987, however, to 13 million smolt.[35] Smolt farmers produced this dramatic increase in smolt to supply the record growth in the salmon farming industry during 1987. The Scottish smolt industry increased their output again during 1988 and 1989 to 22 million and 26 million smolts respectively.

Disease problems hit Scottish smolt producers in 1989. Sea Farm Polly, one of Scotland's largest growers, reportedly lost 1.7 million smolts worth $4 million to disease.[36] Disease problems reduced output through 1991. The 1991 smolt class, however, survived in much larger numbers due to improved and safer methods of disease control. During 1991 Scottish smolt farmers produced 22.4

million smolts. Scottish smolt farmers expect smolt production to be 20 million smolts in 1992.[37]

B. Salmon

Scottish commercial salmon farming grew slowly during the early 1970s.[38] Scottish salmon growers began to harvest larger quantities of Atlantic salmon during 1975,[39] and production grew from 598 t in 1980 to nearly 7,000 t by 1985. Farmed salmon harvests have continued to increase, reaching almost 40,600 t by 1991. (See appendix).

IV. ASSOCIATIONS AND COMPANIES

A. Associations

The Scottish salmon industry is well represented by a number of different groups. **The Scottish Salmon Growers' Association (SSGA)** was one of the first groups established. SSGA created the **Scottish Salmon Board** (SSB) in 1988 and charged it with marketing Scottish-cultured salmon. The SSB controls a $3.5 million marketing budget, which is mostly utilized for promoting Scottish farmed salmon in the U.K. The SSB operates from an office in Perth where it represents 55 companies and 20 sales organizations.[40] As part of its marketing efforts, the SSB helped create the tartan gill tag used to identify member-supplied salmon. SSB also advertises its "Quality Approval Mark" to increase visibility for Scotland's high quality standard, and SSB provides support to British retailers. A sample of the advertisements sponsored by the SSB is highlighted below:

"Even in those lochs sheltered from the sea and placid on the surface, Scottish Salmon are challenged by stiff breezes and powerful currents, working off any trace of extra fat daily. So when they come to market, Scottish Salmon are deliciously fit, an irresistibly even, deep red. And when they're cooked, the salmon meat holds together...beautifully. What's more, Scottish Salmon often come to you 24 hours faster and fresher than salmon from other overseas countries...Scottish Salmon with a bright tartan tag. Call for it."[41]

As another part of its marketing program the SSB created the **Scottish Salmon Bureau** in 1992. The Bureau, which replaced the Scottish Salmon Information Service, is designed to answer press inquiries and questions from the public about Scottish salmon.[42] The Bureau operates a "Scottish salmon hotline" which provides nutritional and purchasing information to consumers. The hotline even hands out recipes, should a consumer request them.

The **Scottish Salmon Smokers' Association** was formed in 1986 to assure that smoked salmon from Scotland is recognized. A well-known Scottish salmon smoker notes that *"Genuine smoked Scottish salmon is a salmon caught or farmed in Scotland that has also been smoked in Scotland."*[43] The distinction is important, because other producers identify their product as "Scottish smoked salmon" -- meaning that their salmon (regardless of source) is smoked in the "Scottish style." Because consumers could not distinguish between this "Scottish smoked salmon" and "Smoked Scottish salmon" (which must be Scottish salmon, smoked in Scotland), the Scottish Salmon Smokers' Association developed the "Scottish Salmon - Smoked in Scotland" gold medal to identify genuine smoked Scottish salmon. Scottish smokers felt a distinction of their product was essential, because they see the "imposter" product as inferior. Scottish smokers, who maintain that they are among the best in the world, do not want their product image tarnished.

The **Shetland Salmon Farmers' Association**, and other groups represent the interests of salmon farmers in the Shetland Isles. Some work independently of the Scottish Growers Association and others work with the group.

Finally, the SSGA established the **Scottish Smolt Producers' Group** in 1989. The Smolt Producers' Group coordinates the efforts of Scottish smolt producers, and works to insure the health and quality of Scottish smolts.

B. Companies[44]

The industry peaked during 1988 when 153 companies operated 434 sites. There were 163 companies operating 365 sites during 1991.[45] Three companies, Marine Harvest, Booker-McConnell, and the Norwegian-owned Norsk-Hydro, dominate the Scottish salmon grow-out industry. Sea Farm (Polly) and Sea Farm (Kerry) dominated Scottish smolt production in the late 1980s but went bankrupt in 1990.[46]

Marine Harvest Ltd, a subsidiary of the Anglo-Dutch conglomerate Unilever, pioneered salmon farming in Scotland. Marine Harvest owns 25 percent of Scotland's salmon production, including 33 freshwater and marine farm sites and two processing plants in the West Highlands. By 1990, Marine Harvest owned 20 different farms throughout Scotland, including smolt producing operations, and produced 9,000 t of salmon.[47] Marine Harvest also operated a salmon farm in Chile in 1990. During March 1992 Unilever, Marine Harvest's parent company, disengaged from the seafood business and put Marine Harvest up for sale. Though Marine Harvest executives report that the company will continue "business as usual," purchase of the company brings with it a substantial share in the Scottish salmon industry. This change in ownership could have profound impact on the industry.

McConnell Salmon Ltd., Scotland's second largest farming company, was established in 1973. The company is a subsidiary of Booker-McConnell and is also a Scottish salmon farming pioneer. McConnell's facilities near Glasgow include 4 hatcheries, 6 freshwater sites, 14 marine sites, and 2 processing plants. The company employed 130 people and produced 2,200 t of salmon by 1991.[48]

Golden Sea Products is a subsidiary of Norsk-Hydro, a Norwegian, state-owned, hydroelectric company. Norsk-Hydro owns Mowi Salmon of Bergen, Norway, and now operates one of Scotland's 3 largest farms.

Sea Farm (Polly) Ltd. was purchased by Sea Farm Group of Norway in 1982.[49] Sea Farm Group later invested in Sea Farm (Kerry) Ltd., another smolt producer.[50] Sea Farm (Polly) Ltd. operated one of the largest smolt hatcheries in Britain until the company went bankrupt in 1990.

V. MARKETS

A. Declining prices

Farmed salmon was a rarity and was priced as a luxury food during the early 1980s. High prices in the early and mid-1980s allowed many firms to survive costly mistakes, diseases, or bad management practices. Later, however, as world harvests increased, salmon farmers were required to reduce their costs to remain competitive. Farmed salmon prices on the UK market declined gradually by about 30 percent between 1980 and 1987.[51] Prices plummeted an additional 40 percent between 1988 and 1989. Then, in 1989, Norwegian harvests began to exceed the ability of the Norwegian exporters to market their salmon profitably. Prices fell sharply and continued to decline through 1991-92. At times the world price for farmed salmon was near $5.00/kg--close to the production cost (estimated at $4.40-$5.50/kg). These low prices left only a slim margin for profit,[52] and drove many less efficient operators out of business.

B. Dumping complaints

Scottish salmon farmers complained in 1989 that subsidized Norwegian salmon was being "dumped" on EC markets, damaging Scottish salmon exports. This, they claimed, was unfair. The British Government requested that the EC study the complaints; the EC agreed to do so in February 1990.[53] Following an investigation, the EC concluded that fresh, farmed Norwegian salmon was sold on EC markets at between 20 and 30 percent below market price. This caused Scottish (and Irish) salmon growers to lose an important share of the EC market. The Commission's investigators recommended that the EC impose an 11.4 percent anti-dumping duty on Norwegian salmon imports.[54] Norwegian assurances that prices were increasing, however, helped defuse the situation.[55] In November 1990, the EC agreed to drop the threatened EC import penalty,[56] based on assurances from the Government of Norway that Norway would consult with the EC directly should future market disruptions occur.[57]

C. Minimum Import Prices

The SSGA reported that prices for Norwegian farmed salmon had declined to "disastrous levels" immediately after the EC announced that it would drop the import duty. The SSGA called for a 21 percent import duty on Norwegian imports into Europe.[58] The Norwegian Fish Farmers Sales Organization (FOS) responded to these complaints by announcing that it would continue to buy and freeze excess fresh salmon in 1991 to maintain or increase prices.[59] Scottish (and Irish) salmon growers, however, were not satisfied with the FOS efforts. In April 1991, the SSGA again alleged that Norway was dumping farmed salmon on the EC market. Norway denied the charge, and accused Ireland and Scotland of attempting to oust Norwegian farmers from the EC

market. John Gummer, UK Minister of Agriculture, Fisheries and Food, expressed his concern with problems facing UK salmon farmers because of low-priced imports from Norway during August 1991.[60] Scottish salmon farmers again asked the EC Commission during September 1991 for protection against alleged Norwegian dumping of farmed Atlantic salmon, complaining that the Norwegians were selling salmon below Norwegian production costs by as much as $1.00/kilogram. The Scots based their claims on the fact that the Norwegians use similar methods and have the same basic cost structure as Scottish fish farmers. The arguments made by the Scottish and Irish salmon producers convinced the EC to adopt new minimum import prices for farmed Atlantic salmon (Regulation 3383/91) on November 8, 1991.

The minimum prices were in effect from November 2, 1991 through February 28, 1992. The EC later extended the minimum prices through May 31, 1992.[61] The EC minimum import prices were important to Scotland, because it exports salmon to fellow EC members.[62] The EC did not reinstate their minimum import price program after the legislation expired, but did indicate that it would not hesitate to reinstate the legislation if needed.

The EC minimum import prices helped stabilize the market for U.K. salmon producers. Scottish exports to France increased by 30 percent during 1991, and Scottish salmon growers were able to increase their share of the domestic market by 34 percent during 1991. During 1992, however, Scottish exports to France fell by 40 percent.

D. Domestic marketing

The UK is the Scottish salmon farmer's principal market. This is a unique feature of Scottish salmon aquaculture because most other salmon producing countries export their salmon products to distant markets. Farmed Atlantic salmon is now the third most popular seafood in the UK, after cod and haddock, and accounts for 15 percent of all fresh and chilled fish consumed in the UK.

1. Fish mongers

In Britain, fish is usually purchased from a small shop where the shop keeper displays a variety of fresh fish in open cases filled with ice: this is the fishmonger. Unfortunately, this is a dying business. In the 1960s there were over 6,000 fishmongers in Britain; by 1991 there were fewer than 2,000.[63] Scottish growers provided 85 percent of the 8,500 t of salmon sold by fishmongers during 1990.[64]

2. Multiples

Supermarkets (called "multiples" in Britain) are rapidly overtaking the fishmonger in sales. During 1990 the supermarket chains sold 7,700 t of salmon, 95 percent of which was Scottish. Though the supermarkets sold less salmon than fishmongers during 1990, supermarket sales doubled in 1989.[65] Traditional fishmongers saw their overall sales static. One major supermarket chain, Marks and Spencers, reportedly sells as much seafood as half of the fishmongers in the UK.[66]

Though the flood of farmed salmon on world markets has led to oversupply, Scottish farmers are overall optimistic that marketing and careful attention to management and quality control will insure them a growing business. In fact, the market for salmon has increased dramatically as world prices fell during 1989-91: overall salmon consumption in the UK more than doubled during 1989-91. During 1990 alone Scottish farmed salmon sales to the UK increased 77 percent. Furthermore, there is still room for considerable market expansion in the UK. According to a study by AGB, Europe's largest research organization, 73 percent of British consumers had never tried salmon as of 1990. According to that figure, if Scottish producers could entice 1 in 10 UK consumers to try salmon, they could increase their sales by 25 percent.

E. Promotion

Scottish producers began to take marketing very seriously in the mid-1980s. They formed the SSB to aggressively market their product and handle general inquiries about the industry in 1988. The organization represents about 55 companies comprising about 60 percent of total Scottish salmon harvests.

1. Tartan quality mark

The "Scottish Quality Salmon" gill tag was established in 1991. This has given the Scottish industry an easily recognizable trademark to focus consumer recognition. The SSB distributes the octagonal, tartan-patterned tag only to members who pass strict quality control restrictions. The tartan-patterned quality mark also allows SSGA members to distinguish their product from inferior quality product, protecting the reputation of Scottish salmon

and allowing the salmon's origin to function as a brand name. Because SSB's marketing efforts hinge on establishing Scottish farmed Atlantic salmon as a high-end quality product, the gill tag and other uses of the tartan quality mark are an important part of assuring that Scottish product is easily recognizable.[67]

2. Retail sales

The SSB has been successful: UK retail sales of fresh salmon increased 34 percent during 1991. Because 80 percent of the fresh salmon sold in the UK is Scottish, this represents a continued upward trend in Scottish salmon sales to the UK. Indeed, in a consumer survey conducted during early 1992, 76 percent of British consumers surveyed stated that they would be willing to pay more for salmon bearing the Scottish salmon tartan mark.[68] The same survey, conducted by Consumer Attitudes Research on behalf of the SSB, found that 75 percent of respondents believed that the tartan mark served as an extra assurance of quality over a supermarket label (65 percent found that it supplemented their fishmonger's reputation). The SSB also launched aggressive promotional campaigns during 1992, including retail incentives such as recipe cards, posters, and contests.

The drive to increase domestic consumption of Scottish salmon has also had an unexpected dividend: imports of salmon have declined from 8,300 t in 1986 to 4,700 t in 1991. [69]

VI. EXPORTS

Scottish salmon exports reached 17,136 t during 1991, a 30 percent increase over 1990 exports. Scotland currently exports around 42 percent of its salmon production, valued at $140 million. Scottish producers estimated that 77 percent of total exports (about 13,160 t) were fresh salmon, 20 percent were smoked salmon (3,360 t), and 2 percent (420 t) frozen. Scottish producers exported the remaining one percent as processed salmon in some other form (paté, canned, etc).

A. France

France is Scotland's largest export market, absorbing 9,900 t of salmon during 1991. Total Scottish salmon exports to France increased by over 30 percent during 1991, and Scottish industry experts expect the trend to continue. Currently, French consumers purchase 58 percent of Scotland's total salmon exports. During May 1992 Scottish Salmon received the prestigious *Label Rouge* quality mark from the French authorities. The mark is recognized by 78 percent of French consumers, and Scottish salmon is both the only imported product and the only fish to receive the mark. This virtually assures Scotland a position in the higher-priced, higher-quality end of the French salmon market.

B. United States

The United States is a growing market for salmon in general, and Scottish salmon exports to the United States grew during 1991. Scottish salmon farmers sell 10 percent of their export production to the U.S. market. During 1990, salmon edged into the top 10 seafoods consumed in the U.S. as the 5th most popular seafood overall. Scottish producers exported over 1,600 t to the U.S. during 1991, despite an unfavorable exchange rate for U.S. currency. Indeed, Scottish salmon has a reputation as a high-quality product among U.S. consumers, and the narrow high-quality salmon market does not appear to be price sensitive.

C. Spain

Spain has increased its imports of salmon dramatically during the past several years, and Scotland has enjoyed a small portion of that market. During 1991, Scottish salmon farmers exported 144 t of salmon to Spain (a 40 percent increase over the 1990 figure of 103 t). However, Norway dominates the Spanish salmon import market, and has announced plans to intensify their marketing effort there. Therefore, it is less likely that this market will expand for Scottish salmon profitably as their other market options.

D. Japan

Sales to Japan are relatively small. However,

Scotland's 1991 salmon shipments to Japan were double those made during 1990, increasing from 396 t in 1990 to 784 t in 1991.

E. Germany (FRG)

Germany imported 327 t of Scottish salmon during 1990.[70] Of those imports, 85 percent were imported fresh (277 t), and only 1 ton was frozen. The remainder (49 t) were imported processed, mostly as smoked salmon. During 1991, German consumers purchased 440 t of Scottish salmon. Thus, though the German market for Scottish salmon is small, it has shown healthy growth (a 30 percent increase in sales from 1990 to 1991).[71]

F. Others

Consumers in Scotland's other European markets are also buying more salmon. Scottish salmon exports to other EC countries increased by 38 percent during 1991. Scotland's other 1991 European markets include, in order of importance: **Italy** (1,160 t, 7 percent of total exports), **Belgium** and **Luxembourg** (1,017 t, 6 percent of total exports), the **Netherlands** (886 t, 5 percent of total exports).[72] Scottish salmon farmers also do a steady but small trade with **Switzerland**.

VII. CURRENT PLANS

A. Marketing campaign

Despite a continued price slump, Scottish farmed salmon production continued to expand modestly during 1991 and reached around 40,600 tons. Thanks to active marketing techniques, Scottish fresh, farmed salmon sales in the UK increased by 34 percent during 1991. Because Scottish farmed salmon cost about the same as many cuts of beef in the UK, Scottish salmon was well poised to gain market share during 1991 despite continued recession in the UK. Considering that UK seafood sales decreased slightly overall during 1991, the fact that Scottish salmon continues to enjoy strong sales increases in the UK is promising. Scottish salmon farmers could continue to expand their UK markets, especially in light of the EC salmon minimum import price. This will keep the price of Norwegian salmon at a higher level, thus increasing the tendency of British consumers to go ahead and "purchase up" to the Scottish product (which the British consumer generally expects to be of higher quality).[73]

Judging from SSB's 1992 promotions which have already been launched, the Scottish have no intention of lessening their marketing onslaught in the UK; by February 1992 the SSB had announced a new advisory service, the Scottish Salmon Bureau, to handle inquiries from consumers and the press. The Scottish Salmon Board also administers a hot-line which can provide recipes, supply nutritional value information, or answer almost any question regarding Scottish salmon.

B. Adding value

Scottish salmon farmers are also increasingly integrating their production operations to include value adding. Because the market for salmon has remained strong, farmers who manage carefully can often turn a profit in their value adding operations to cover the deficits suffered in their salmon farming businesses. Indeed, the recent price slump for farmed Atlantic salmon has slimmed down Scottish production to only those farms which were extremely efficient -- often the larger, more vertically integrated producers. Scottish production is therefore likely to continue to increase at a modest rate during 1992, with increased market share in the UK absorbing much of the increased production.

C. Tighter supplies

Scottish salmon farmers may benefit from two other trends in the EC salmon market. First, observers are predicting (based on smolt production and purchases in Norway) that Norwegian farmed salmon production will fall short of the 120,000 t which the Norwegian government officially forecast.[74] Because 120,000 t already represents a decrease from 1991 Norwegian production, there should be relative stability in the supply of farmed Atlantic salmon on the market in 1992. Supply may even be somewhat tighter. This will hopefully lead to a more stable world farmed Atlantic salmon price, and will allow Scottish salmon farmers more financial margin.

D. EC quality rules

Recent EC regulations regarding seafood safety may serve as a significant barrier to entry for non-member producers of farmed salmon. While the new laws apply mainly to processed product, most processors must undertake extensive refurbishment of their processing and handling facilities to comply.

These new, strict quality control measures come into effect on January 1, 1993. While most EC producers began modifying plant and procedures during 1991 in anticipation of the new regulations (with EC funding assistance in many cases), some non-member producers are unable to do so because of the financial strain on the fishing industry. The EC may see a decrease in imports during 1993 if non-members cannot comply with the regulations by that time. As an EC member, Scotland may be poised to assume any market share left unsupplied by such a decrease in imports from non-EC members.

E. Farm management

Scottish salmon farming companies are now collaborating in management programs and disease control. As part of this move, companies are encouraged to leave sites fallow to allow for year class separation. Not only does this aid in the control of disease, it also allows the seabed to recover from the effects of intensive aquaculture. Following a 1991 survey, only 84 of 286 sea cage sites reported that they were leaving cages fallow. Among freshwater cage sites, 54 of 57 reported leaving cages fallow. Because of industry pressure, compliance with this program is likely to increase during 1992. This may have a slight dampening effect on production, but the chief indicator of production is always smolt production and sales. During 1992, Scottish salmon farmers put fewer smolts in their cages. Production for 1992 and 1993 year classes should remain steady, or decrease slightly, from the 1991 figure.

VIII. OUTLOOK

The Scottish salmon industry appears to be well poised for profitable sales in 1992 and 1993. Reductions in smolt production in the late 1980s and early 1990s mean that supplies will be lower, but this will be offset by higher prices. Sales in the EC should improve, both in terms of quantity and price. Competition from Norway could be reduced during 1992 (and possibly in 1993) in both Europe and the United States because of internal difficulties in the Norwegian industry. If disease does not resurface, and barring heavy losses due to weather, harvests in 1993 could reach 45,000 tons.

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EXCHANGE RATES:

US$1.00 = Pounds sterling (£)

1991 = £.57
1990 = £.51
1989 = £.64
1988 = £.54
1987 = £.55
1986 = £.68
1985 = £.77
1984 = £.75
1983 = £.66
1982 = £.57
1981 = £.49
1980 = £.43

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ENDNOTES

SECTION I (General)

1. Scottish refers only to Scotland. British refers to Scotland, England, and Wales. The United Kingdom refers to Scotland, England, Wales, and Northern Ireland.

2. Dennis Weidner, "British Salmon Industry, 1983-84,"*International Fishery Report* (no date), p.3.

3. In 1991 the Highlands' output declined to only 37 percent of Scotland's total harvests.

4. Ted Needham, "Fish farming in Western Isles of Scotland," *Sherkin Comment*, Autumn 1988, p.12.

5. "Farmers Band Together to Sell Salmon," *Seafood News*, April 1991, p. 21.

6. Information on the Orkney Islands comes from "Salmon Farmers Work Together on Marketing," and "Orkney Council Aids Industry," *Seafood News*, January 1992.

7. "Salmon Farmers Work Together on Marketing," and "Orkney Council Aids Industry," *Seafood News*, January 1992.

8. Roger Fitzgerald, "The Scots Storm the Salmon Scene," *Seafood Leader,* Winter 1987, p. 78.

9. *Ibid.*

10. Susan Pollack, "The Salmon Farms of Shetland," *Seafood Business*, July/August 1987, pp. 41-45.

11. "Industry Brings in its own Mark of Quality," *Fish Farming International*, January 1987.

12. William Crowe, Marketing Administrator, Scottish Salmon Board, fax dated August 19, 1992.

13. Roger Fitzgerald, "The Scots Storm the Salmon Scene," *op cit.*, p. 78.

14. *Ibid.*

15. This figure is greater than suggested by the employment figures provided in Appendix 2. However, current employment figures for 1990 are not available.

16. The information on this section was obtain from Ian M. Whitelaw, "Structure and Administration of the Scottish Salmon Farming Industry," *Aquaculture: A Review of Recent Experience,* Organization for Economic Co-Operation and Development, Paris, 1989, pp. 206-212.

17. Many environmental and tourist interests express concern about the environmental impact of salmon farming. They also consider the "scenic degradation" of Scottish Highlands and Islands areas by salmon farming sites destructive.

18. Ray V. Arnaudo, *The U.K. Salmon Aquaculture Industry*, an unpublished report prepared in 1985.

19. *Ibid.*

20. Both programs have now been stopped.

SECTION II (Problems of Culture)

21. See page 174 (Section VII. E.) for more information on Scottish salmon farmers' cooperation in areas of disease control.

22. Stephen Drummond Sedgwick, *Salmon Farming Handbook*, (Farnham, Surrey, UK: Fishing News Books, Ltd., 1988), p. 167.

23. Norwegian salmon farmers lost large numbers of salmon when the storm destroyed nets and cages. In addition to the economic effects the losses had on an already ailing salmon aquaculture industry, the lost farmed stock pose a threat to the genetic integrity of Norwegian wild salmon stocks. Ecologists are concerned, because farm breeding causes certain noticeable defects in salmon (such as shorter lower jaws and abnormal fin development) which could damage the gene pool of wild populations. For more information, see *Seafood International*, March 1992, or *Norinform* publications from January - March, 1992.

24. Susan Pollack, "The Salmon Farms of Shetland," *Seafood Business*, July/August 1987, p. 43.

25. "Controlling Nature's Predators on Fish Farms" reported in "Fish Farm Dilemma," *Marine Conservation*, Winter 1988/89.

26. "Fish Farms Blamed for Seal Deaths," *The Times*, August 16, 1989, "Rogue Fish Farm Boss Shot Seals Illegally, *West Highland Free Press*, August 4, 1989, and "Fish-farm Manager Fined for Shooting at Seals," *Press and Journal*, August 11, 1989.

27. William Crowe, Marketing Administrator, Scottish Salmon Board, fax dated August 19, 1992.

28. "Animal Lovers in Seal Appeal,", *Press and Journal*, September 2, 1989.

29. "Fish Farms Plundered by Mink," *Press and Journal*, September 13, 1989 and "Fish Farming and Otters," *Press and Journal*, September 25, 1989.

30. "Thousands of Pounds Lost as Vandals Attack Fish Farm," *Oban Times*, September 21, 1989.

31. Canthaxantine, also known as E160g, accumulates in the retina of people who ingest it in large quantities. Researchers are unable to say if the buildup in the retina is harmful. "Fresh Doubts over Safety of Salmon Feed Additive," *Eurofish Report*, September 14, 1989.

32. "Nuvan blinds wild salmon," *Fishing News*, October 27, 1989 and Roger Highfield, "Fish Farm Drug Blinds Salmon", *Daily Telegraph* , October 24, 1982, p. 36. This charge, however, drew strong rebuttals from the Scottish salmon growers who noted that their fish -- the fish directly treated with Nuvan -- did not develop cataracts and did not go blind. The UK Government is allowing Nuvan/Aquaguard to be used through 1992 and 1993.

33. "Two More Years for Aquaguard," *Fish Farming International*, July 1990.

SECTION III (Harvests)

34. Information on smolt production provided by Golden Sea Produce, Ltd., South Shian Connel, Argyll, Scotland.

35. *Fish Farming International*, Vol. 14, (May 1987). p. 21.

36. Peter Redmayne, "Salmon is Special in Scotland," *Seafood Leader*, September/October 1990, p. 68.

37. Lilian Smith, Marketing Administrator, Scottish Salmon Board, fax dated June 16, 1992.

38. Roger Fitzgerald, "The Scots Storm the Salmon Scene," *op cit.*, p. 78.

39. Susan Shaw, Economies of Scale and Salmon Aquaculture, presented at *Aquaculture Europe,* October 2-4 1989.

SECTION IV (Association and Companies)

40. Peter Redmayne, "Salmon is Special in Scotland," *op cit.*, p. 68-73.

41. An advertisement in *Seafood Business Report,* March/April 1991, pp.111.

42. "Helpline Starts," *Seafood News*, February 1992.

43. Peter Redmayne, "Salmon is Special in Scotland," *op cit.*, p. 79.

44. Much of the information on Scottish salmon companies is fairly old. It is sometimes difficult to keep up to date on rapid changes in the industry from a distant vantage point.

45. Department of Agriculture & Fisheries for Scotland, 1992.

46. William Crowe, Marketing Administrator, Scottish Salmon Board, fax dated August 19, 1992.

47. Peter Redmayne, "Salmon is Special in Scotland," *op cit.*, p. 68.

48. Tom Wray, "McConnell Salmon Now has 14 Sea Cage Sites," *Fish Farming International*, (no date), p.26.

49. Sea Farm Group was founded in 1971 by Norwegian investors. The company owns, or has invested in, salmon farms throughout the world. The Sea Farm Group, for example, had 12 smolt farms operating in Norway, Scotland, Canada, and the United States in 1986. It no longer operates in Scotland.

50. "Sea Farm Boosts Scottish Supply of Salmon Smolts," *Fish Farming International*, July 1986, pp. 12-13.

SECTION V (Markets)

51. Susan Shaw, *Markets in Europe for Selected Aquaculture Species, 1989*, p. 28.

52. DPA Group, Inc. *Cost Production Model for Pen Rearing of Salmon*, 1987.

53. *Official Journal of the European Communities*, a notice of intention for an anti-dumping proceeding concerning imports of fresh Atlantic salmon from Norway (No. C 25/6).

54. "EC upholds Norwegian salmon dumping charge," *Fishing News*, October 12, 1990.

55. Regulation (EEC) No. 2423/88.

56. The *Corrigendum to Commission Decision 91/142/EEC of 15 March 1991 terminating the anti-dumping proceeding concerning imports of Atlantic Salmon originating in Norway* was published in the *Official Journal of the European Communities* on March 21, 1991, officially ending the EC anti-dumping investigation.

57. *NORINFORM,* November 20, 1990 and *Eurofish Report*, December 6, 1990.

58. *Eurofish Report*, December 6, 1990.

59. U.S. Embassy, Oslo, January 17, 1991.

60. "UK concern over prices," *Fish Farming International*, September 1991, p. 42.

61. Trond Wøld, Deputy Secretary General of the Norwegian Fish Farmers' Association apparently agreed when he stated that the NFFA would like to see the minimum import prices extended for another three months. *Eurofish Report*, June 4, 1992, pp. FS/2.

62. The new minimum prices are quoted in *Seafood News*, March 1992, *Seafood International* April 1992 (full listing in sources).

63. Katherine Marris, "Scots's Salmon Push Pays off in Britain," *Seafood Business Report*, March/April 1991, pp.110-112.

64. Katherine Marris, "Scots's Salmon Push Pays off in Britain," *op cit.*, pp.112-114.

65. *Ibid.*

66. Katherine Marris, "Scots's Salmon Push Pays off in Britain," *op cit.*, pp.110-112.

67. The industry expressed some concern before SSB introduced the quality mark that consumers could not distinguish between "smoked Scottish salmon," which is Scottish product smoked in Scotland, and "Scottish smoked salmon," which connotes salmon of any origin smoked in the Scottish style.

68. "Tartan mark 'a success'," *Seafood International*, May 1992, p. 6.

69. DAFS, Atlantic Salmon Trust, Government trade statistics provided by Lilian Smith, Marketing Administrator, Scottish Salmon Board, in a fax message dated June 16, 1992.

SECTION VI (Exports)

70. Preliminary figures, based on 1991 statistics of Statistisches Bundesamt, Wiesbaden, FRG.

71. The Scottish Salmon Board, 1992.

72. Scottish Salmon Board, 1991.

SECTION VII (Current Plans)

73. Indeed, a study conducted during January 1992 showed that 75 percent of the UK consumers questioned expected Scottish salmon to be of higher quality than other sources. Approximately 75 percent of those questioned also stated that they would pay more for the added assurance of quality and freshness which they expect from Scottish salmon. *Seafood News*, Vol. 3, No. 4, April 1992, p. 27.

74. Indeed, because low prices and active generic promotions have expanded the world market for farmed salmon, some observers forecast a shortage of salmon by late 1992. These observers reportedly base that judgement on estimations that Norwegian salmon farmers, by far the world's largest producers, will decrease production to as little as 80,000-90,000t during 1993.

Appendix E

United Kingdom (Scotland)

Table 1.--U.K. Salmon supply, 1980-91.

Salmon source	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric Tons											
Farmed salmon	598	1,133	2,152	2,536	3,912	6,921	10,338	12,721	17,950	28,553	32,350	40,593
Wild salmon	1,088	1,726	1,378	1,653	1,358	1,274	1,568	1,200	1,000	1,000	625	650
Imports	6,105	7,311	7,463	8,159	7,739	7,718	8,304	8,200	7,650	5,700	5,600	4,656
Exports (minus)	989	1,023	1,430	1,629	2,626	3,770	5,770	8,200	9,344	12,495	13,150	17,136
UK Supply	6,802	9,147	9,563	10,719	10,383	12,143	14,440	13,921	17,256	22,758	25,425	28,763

Sources: Susan A. Shaw, "Markets and Marketing Systems for Scottish Farmed Salmon, Aquaculture: A Review of Recent Expereince, Organization for Economic Co-Operation and Development, Paris, 1989, p. 159 (1980-1986) and Department of Agriculture and Fisheries for Scotland, Atlantic Salmon Trust, Government Trade Statistics (1987-1991), sent by the Scottish Salmon Board via fax message dated June 16, 1992.

Table 2.--U.K. Employment in salmon farming, 1980-91.

Employment	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Full-time	152	205	232	283	387	528	733	608	991	-	-	1,014
Part-time	31	56	65	89	128	193	206	198	329	-	-	272
TOTAL	183	261	297	372	515	721	939	806	1.320	2,500	5,000	6,500

Sources: "Salmon and Trout Farming in Scotland," *Report of DAFS Annual Survey*, 1979-84 and 1986-88.

Table 3.--U.K. Atlantic salmon farming, 1976-91.

Year	Smolt Production	Salmon harvests
	Millions	*Metric Tons*
1976		140
1977		220
1978		430
1979	.8	520
1980	1.4	598
1981	1.5	1,133
1982	1.7	2,152
1983	2.9	2,536
1984	3.6	3,912
1985	5.6	6,921
1986	6.6	10,337
1987	13.3	12,721
1988	22.5	17,951
1989	25.8	28,553
1990	24.9	32,350
1991	22.4	40,593

Source: U.S. Consulate General, Edinburgh, Department of Agriculture and Fisheries for Scotland, Angus Morgan, The Status and Prospects for Aquaculture in the U.K., Marketing Committee of Scottish Salmon Growers Association and the Scottish Salmon Bureau. p - Projection. Note: The 1987 harvest is frequently reported as 12,271 tons.

Table 4.--U.K. Atlantic salmon farming industry, 1970-91.

Year	Salmon farms			
	Firms	Fresh	Sea	Total
	Number			
1970	1	1	0	1
1971	2	2	1	3
1972		4	1	5
1973		6	3	9
1974		8	3	11
1975		11	4	15
1976		11	5	16
1977		13	9	22
1978		15	14	29
1979		20	18	38
1980		23	22	45
1981	32	27	35	62
1982	41	37	46	83
1983	49	41	62	103
1984	67	46	83	129
1985	104	66	128	194
1986	113	111	168	279
1987	126	11	196	207
1988	153	176	258	434
1989				
1990				298
1991	163			365

Table 5.--U.K. Farmed Atlantic salmon exports, 1980-91.

Year	Exports			Total Quantity
	Fresh	Frozen	Smoked	
	Metric Tons			
1980	314	537	335	851
1981	495	398	330	893
1982	624	627	467	1,251
1983	1,000	441	483	1,441
1984	1,789	548	594	2,337
1985	2,942	461	729	3,403
1986	4,277	681	788	4,958
1987	4,828		1,120	NA
1988			1,172	NA
1989	9,557		1,534	NA
1990	9,489		1,868	NA
1991				NA

Source: Sea Fish Industry Authority (1983-85) and Eurostat (EC) trade staistics (1980-82). David P.D. Jolly, Keynote Report, United Kingdom, JETRO International Forum on Salmons and Trouts, p. 22. Minor adjustments have been made to make the data agree with data shown in other tables.

Table 6.--UK. Exports of farmed salmon, by country and quantity, 1980-91.

Country	Salmon Exports						
	1980	1982	1984	1986	1988	1990	1991
	Metric Tons						
France	598	926	NA	NA	5,131	7,640	9,892
Netherlands	239	496	NA	NA	818	477	886
Ireland	509	455	NA	NA	-	-	-
United States	44	197	NA	NA	753	1,446	1,665
Denmark	43	111	NA	NA	-	-	-
Benelux	70	107	NA	NA	349	847	1,017
Italy	21	44	NA	NA	587	961	1,161
Switzerland	23	32	NA	NA	-	-	-
Australia	13	21	NA	NA	-	-	-
South Africa	44	17	NA	NA	-	-	-
Hong Kong	14	13	NA	NA	-	-	-
Germany	3	7	NA	NA	339	327	440
Spain	39	7	NA	NA	183	103	144
Other	268	141	NA	NA	1,024	953	1,147
TOTAL	1,928	2,574	2,776	5,746	9,184	12,754	16,352

Source: Eurostat trade statistics and Sea Fish Industry Authority
NA=Not Available

Table 7. --U.K. Exports of smoked salmon, 1980-88.

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988
	Metric tons								
France	70	107	89	111	125	155	208	334	322
Sweden									
Ireland		14	30	16	8	5	2	2	2
Italy					40	74	105	194	310
Belgium/Lux	28	16	23	23	25	29	26	73	82
Netherlands			1				21	66	84
U.S.A.	44	40	157	115	197	226	211	217	171
Other	193	153	167	218	199	240	215	234	201
TOTAL	335	330	467	483	594	729	788	1,120	1,172

Source: Sea Fish Industry Authority

Table 8.--UK. Exports of fresh/chilled salmon, 1980-86.

Country	1980	1981	1982	1983	1984	1985	1986
	Metric tons						
France	212	415	538	814	1,142	1,428	2,270
Belgium	26	12	10	45	52	55	109
Ireland	30	34	33	41	100	134	95
Netherlands	17	15	24	-	380	659	901
Germany	-	5	-	54	23	54	128
USA	-	-	-	-	45	533	576
Canada	-	-	-	-	-	-	54
Denmark	13	-	-	-	-	-	40
Switzerland	-	-	-	-	-	-	37
Others	16	14	19	46	47	79	67
Total	314	495	624	1,000	1,789	2,942	4,277

Source: David P.D. Jolley, London Fish Merchants Association, Keynote Report - United Kingdom, JETRO International Forum on Salmons & Trout, p.22.

Table 9.--UK. Exports of frozen salmon, 1980-86.

Country	1980	1981	1982	1983	1984	1985	1986
	Metric tons						
France	316	206	299	170	165	143	235
Netherlands	11	9	49	33	16	9	27
Belgium	7	22	42	22	5	19	20
Denmark	30	-	136	52	14	32	66
Ireland	52	47	22	48	120	129	161
Germany	3	41	7	24	36	10	12
USA	9	-	3	2	49	21	1
Switzerland	7	7	25	34	52	11	8
South Africa	13	15	1	-	-	15	99
Others	99	67	43	92	91	72	52
Total	537	398	627	477	548	461	681

Source: David P.D. Jolley, London Fish Merchants Association, Keynote Report - United Kingdom, JETRO International Forum on Salmons & Trout, p.22.

Chapter X

North and South America

COHO SALMON

(Oncorhynchus kisutch)

Artwork courtesy of the Association of Chilean Salmon Farmers

Chapter X
North and South America

CANADA

Canada is currently the world's fourth largest producer of farmed salmon. Commercial salmon farming in Canada began in 1972 with the establishment of the first salmon farm in British Columbia which used surplus eggs from a Canadian government hatchery. The first successful attempt at farming salmon in Atlantic Canada occurred in New Brunswick in 1978. Between 1972 and 1984, the industry remained undeveloped and produced very small quantities of salmon. For example, only 200 metric tons of salmon were produced in 1981, an almost negligible amount when compared to the production in Norway, the United Kingdom, and Japan. Norwegian fish farmers began to invest in Canada in 1984, and the "gold rush" to establish salmon farms began, setting the stage for rapid expansion of Canadian salmon production. The majority of the industry's development occurred between 1986 and 1989, when most of the current salmon farming sites became operational. The production of farmed salmon in Canada increased dramatically, rising from 1,037 tons in 1986 to 18,030 tons in 1989. World salmon harvests also increased significantly in the late 1980s, rising from 47,800 tons in 1985 to 209,510 tons in 1989. That year, Norwegian overproduction flooded the market, causing the price of farmed salmon to decline 30 to 40 percent. The price collapse accelerated the restructuring of the salmon farming industry, particularly in British Columbia. Consolidation and reorganization of existing companies took place to minimize vulnerability to price decreases, redistribute assets within the industry, and thus, improve overall operational efficiency. As a result, the industry became stronger. Canadian farmed salmon production approached 21,500 tons in 1990 and totaled approximately 27,700 tons in 1991.

The growth of the Canadian salmon farming industry has been influenced by 4 important factors or events. First, demand for farmed salmon is strong and growing, particularly in North America. Consumers want to be able to obtain fresh salmon in months when the conventional wild salmon fishery is closed, and their preferences are continually shifting to healthier seafood products. Second, the conditions for salmon farming in Canada are excellent. British Columbia especially offers miles of pristine coastline and climatic conditions that are quite favorable to salmon farming. Third, the surge of farmed salmon production in Canada was also stimulated by increasing world production and the good earnings generated by salmon farmers around the world through 1988. Fourth, Canada was ideally positioned to replace Norway as a key supplier in 1991 when the United States Government introduced stiff anti-dumping and subsidy tariffs on imported Norwegian farmed salmon. This allowed Canadian processors to expand their production to fill void left by Norway.

The future of the Canadian salmon aquaculture industry looks promising. The 27,000 tons of farmed salmon harvested in 1991 has been valued at almost C$215 million, and total Canadian farmed salmon production is expected to reach 30,000 tons in 1992 with an estimated value of C$225 million. The reorganization of the industry strengthened its ability to compete successfully in the highly competitive world salmon market. Canadian salmon farming is poised to move forward at a time when many suppliers have had to decrease their farmed salmon harvests. The Canadian salmon industry must continue to be cost-effective in the future, however, in order to meet the challenge posed by Chilean salmon entering the U.S. market. Fortunately, Canada has a comparative advantage with respect to supplying the U.S. market over other producing nations. Canada's close proximity to the United States and its well-established ties to U.S. consumer markets will facilitate attempts to boost the consumption of Canadian farmed salmon in the United States.

Figure 1.--Salmon farm on Vancouver Island in British Columbia.

CONTENTS

INTRODUCTION

The Office of International Affairs follows the development of the farmed salmon industry in Canada as part of its examination of the world farmed salmon industry.

In the following report, brand names or the names of companies have been included. **It is not the policy of the Department of Commerce to endorse any product or company.** Likewise, the omission of any product or company is not an indication of any disapproval by the Department of Commerce.

There may be a few discrepancies in some of the tables and graphs provided. It is extremely difficult to obtain complete production statistics, and sources often report slightly different figures for the same regions.

ACKNOWLEDGEMENTS

I wish to acknowledge the British Columbia Salmon Farmers Association and the New Brunswick Salmon Growers Association for their assistance in providing statistical data for this report. The Canadian Department of Fisheries and Oceans was also extremely helpful in gathering information for this project and helping account for statistical discrepancies in data provided by different sources.

I. BACKGROUND AND OVERVIEW

A. Species

Three species of salmon are currently being farmed in Canada. Atlantic salmon (*Salmo salar*) is the species of choice in Atlantic Canada, which includes the provinces of New Brunswick, Newfoundland, Nova Scotia, and Quebec. Chinook salmon (*Oncorhynchus tschawytscha*) is presently the dominant species raised in British Columbia (B.C.), although Atlantic salmon is becoming increasingly popular on the Pacific Coast. Coho salmon (*Oncorhynchus kisutch*) is also farmed in B.C., but to a continually lesser degree.

B. Overview

1. General

Salmon aquaculture is quite beneficial to the Canadian economy, because salmon farms can be located in sparsely populated areas where they contribute significantly to regional economic development. The industry has provided full-time jobs in areas where unemployment is traditionally high and employment opportunities are seasonal. Additionally, because catches of certain groundfish and shellfish harvests have declined in recent years, fish farming is welcomed as an alternative source of high-value species that will not compete with the existing conventional fisheries. Thus, the development of the industry has been strongly supported by both the federal and provincial governments.

The size and structure of salmon farms varies significantly in Canada. Therefore, the number and size of salmon pens differs between sites. In British Columbia, there is a trend towards multi-site farms; many farms currently operate two or more sites. The use of multi-site operations permits salmon growers to expand the grow-out capacity of their farms and benefit from economies of scale in salmon production. In addition, extending production over a number of sites decreases the risk associated with outbreaks of disease and limits the effects of natural disasters. In Atlantic Canada, on the other hand, single site farms are predominant. The availability of attractive sites is limited by low water temperatures and the seasonal presence of ice throughout a large part of the region. Moreover, the provincial governments in Atlantic Canada seem to prefer an industry with a large number of small-sized farms that are locally-owned rather than an industry dominated by a few large owners.[1]

As world production of farmed salmon has increased, the market has become more competitive, dictating that individual firms improve cost-effectiveness in order to remain viable. Restructuring of the Canadian salmon farming industry began in the late 1980s to adjust to the market pressures and was accelerated by the 1989 price decline. In B.C., consolidation has occurred as smaller farms have been either partially or fully bought out by larger firms. In Atlantic Canada, a different type of restructuring transpired; about 60 percent of the salmon farms marketed their product through a cooperative effort by 1988. A trend towards integrated operations in the Canadian aquaculture industry has also emerged. Many farms have integrated backwards to operate hatcheries or

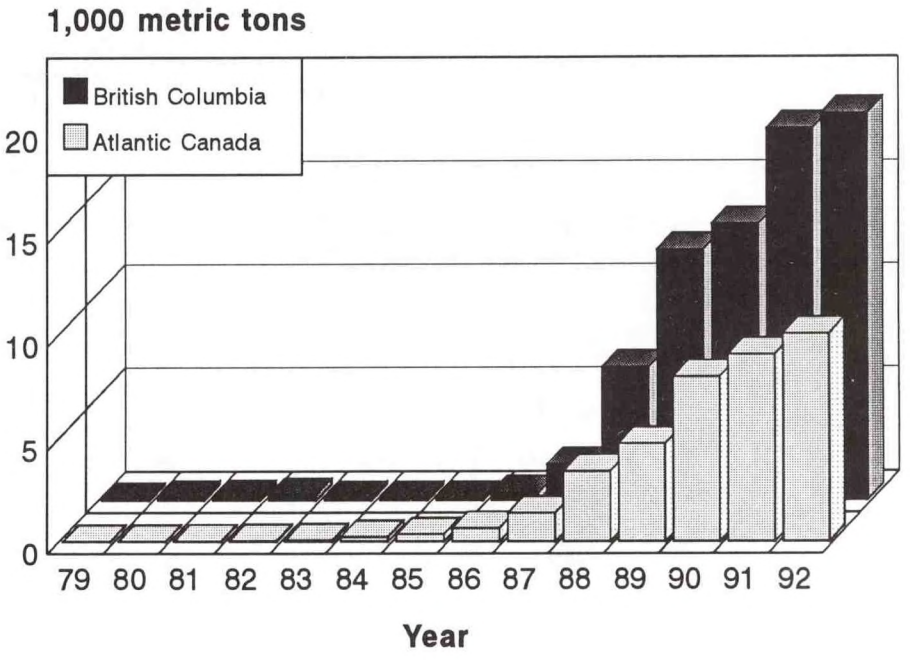

Figure 2.--Canada. Farmed salmon harvests by region, 1980-91, with projections for 1992.

produce feed, and some have created forward linkages into processing and distribution activities.[2]

Canadian production of salmon on both coasts has grown from 168 metric tons (t) in 1980 to 22,975 t in 1990, increasing the Canadian share of world production from 1 percent to 8 percent in 10 years. This gain in the share of world production occurred at a time when all salmon producers were increasing harvests. Estimates from 1991 show Canadian production to be around 27,000 tons. The industry has grown significantly, but not to the degree originally believed possible. For example, Canadian farmed salmon production was once expected to reach 28,000 t by 1990 and 32,300 t by 1991.[3] Production in B.C. has been lower than many of the forecasts, but production in Atlantic Canada has exceeded expectations for the most part (see Table 1 in Appendix F.1).

2. Impediments to expansion

Despite the rapid growth that has taken place in the past few years, Canada's salmon aquaculture industry has been limited by several important impediments. These include:

Availability of smolts -- Until the late 1980s, the federal government was the main supplier of smolts to the private sector in British Columbia. These smolts included surplus fish used primarily to enhance or maintain wild stocks. The Canadian Department of Fisheries and Oceans (DFO) decided in the mid-1980s to allow private hatcheries to raise salmon smolts for sale to commercial fish farmers, allowing DFO to concentrate on raising smolts for rebuilding wild stocks in both the Pacific and Atlantic Oceans. Before a sufficient number of private hatcheries had been constructed, however, the salmon farming industry in B.C. began expanding rapidly. The supply of eggs provided by the government remained limited, resulting in a supply shortage which was filled by foreign suppliers of eggs, especially Scotland. There was concern at this time that smolt shortages would persist for a few years, impeding the growth of Canada's salmon farming.[4] By 1989, however, 40 hatcheries were operating in B.C., half of them combined with grow-out sites. That same year, the hatcheries produced approximately 29 million smolts, making B.C. self-sufficient in terms of smolt production.[5] The growth of the Atlantic salmon farming industry was also restricted somewhat by limited smolt production until the late 1980s. While privately owned hatcheries supplied 80 to 85 percent of demand, the remainder had to be provided from excess DFO stocks of "wild" salmon smolts bred to survive in the open sea.[6] As of 1990, there were 12 private hatcheries in New Brunswick and 8 in Nova Scotia expanding production to meet the demand for smolts of a "domesticated" strain of salmon preferred by fish farmers.[7] One of the most recent problems with smolt occurred in Newfoundland in 1988 when the use of poor quality broodstock resulted in the loss of farmed smolts and market fish to infection.[8]

Feed supply -- The availability of low-cost feed for hungry -- and expensive -- inventories of fish is a key constraint. Feed is typically the single largest cost facing salmon farmers; it takes approximately 2 kilograms (kg) of feed to produce a fish that weighs 1 kilogram. The Canadian aquaculture industry buys its food primarily from local producers and imports the remainder from suppliers in the United States and Europe. Currently there are 3 feed producers in Pacific Canada, two of which are Norwegian owned and one of which is a subsidiary of a U.S. firm. Most of the fish food used in Atlantic Canada is produced locally. Dry feed was introduced to Canadian fish farmers in the late 1980s. Abundant stocks of herring and capelin in Canadian waters are an important long-term asset that will benefit Canadian fish farmers in the future. Inexpensive sources of high-protein herring and capelin meal will provide Canadians with an independent supply of inexpensive feed as the cost of feed continues to grow in world markets.[9]

Biotechnical expertise -- Canadian fishery biologists and scientists have a reputation for excellence which should serve their salmon industry in the future. However, some of the knowledge of nutrition, diagnostics, diseases, and genetics of salmon farming is only now evolving in Canada as compared with over 20 years experience in Norway. There is greater biotechnical knowledge available with respect to Atlantic salmon than there is for chinook and coho salmon raised in B.C. The Federal DFO undertakes extensive research at biological stations on both coasts and is rapidly expanding its ability to provide meaningful support to the industry. Moreover, the provincial governments, private sector, and educational institutions are all working to expand biotechnical expertise in salmon farming. In Atlantic Canada, for example, the Atlantic Salmonid Demonstration and Development Farm was established to help local salmon farmers. The farm was part of a 3-year program to study salmon farming in Atlantic Canada and that project reportedly ended in July 1989. The DFO also has extensive support programs in other areas of aquaculture which help

support the salmon farming industry. As the body of scientific data expands, the knowledge will provide Canada with a better foundation on which to base the further growth of its farmed salmon industry.[10]

Availability of capital -- The availability of both start-up capital and working capital remains an important constraint limiting the expansion of salmon aquaculture in Canada. The average time that it takes Pacific salmon to grow from a smolt to market size is 2 to 3 years; Atlantic salmon, which has a longer smolting period, has a grow-out period of 18 to 24 months. Salmon farmers, thus, do not receive a return on their investment for at least two years after beginning operations. Lack of knowledge about fish farming, as well as uncertainties about future prices for fresh salmon, have made many bankers reluctant to provide financing to the industry. Prospective farmers often cannot obtain loans to begin farming, and even established farmers have difficulty borrowing funds to maintain their operations. Foreign investment (mostly from Norway and the United States) has provided some assistance, particularly in B.C., but the problem remains.[11] Fortunately, the new Bank Act in Canada, which came into force on June 1, 1992, has been revised to make it easier for aquaculturalists to gain access to financing. Section 427 of the Act allows fish held in inventory by aquaculturalists to be used as collateral for securing bank loans.[12]

Growing public resistance -- Aquaculture is meeting resistance from fishermen, homeowners, environmentalists, and other interests who oppose its further expansion. Commercial fishermen, for example, fear that disease may be transmitted from farmed to wild stocks. Sports fishermen are concerned about nets and pens blocking access to local fishing grounds. Homeowners are concerned about the value of their property declining with the influx of fish farms obstructing views and polluting pristine waters. Environmentalists are worried about the accumulation of wastes and the use of chemicals affecting the natural environment. Biologists are concerned about genetic changes in wild fish when farmed fish escape to breed with wild varieties. Government officials are concerned about the introduction of aquatic parasites that could upset the natural balance of life of the area. Thus, wide-apread popular resistatnce could slow future expansion.[13]

Economic competition -- Canadian salmon farmers must compete with the international market. World production of salmon climbed from 7,200 t in 1980 to over 325,000 t in less than a decade. The increase in Norway's production of salmon, in particular, as well as the influx of new countries producing significant amounts of salmon, was so sharp that during 1989-91 markets became saturated and prices declined sharply. Many individual farms went into bankruptcy. The Canadian industry, however, is emerging stronger; the reorganization efforts improved efficiency and encouraged companies to vertically integrate their operations. Canadian fish farmers, however, will have to continue producing high quality salmon and focus their efforts increasingly on marketing in order to compete.

Competition from Norway in the U.S. market has been temporarily curbed. The United States imposed stiff anti-dumping and subsidy tariffs on imported fresh and chilled salmon from Norway in 1990-91. The U.S. International Trade Commission (ITC) determined that Norwegian farmed salmon was being sold at less than fair value in the United States and thus was injuring U.S. salmon farmers. U.S. imports of Norwegian salmon decreased from 9,450 t in 1990 to 1,320 t in 1991. Canadian processors were able to take advantage of this situation and began expanding their production to fill the void left by Norway. Between 1990 and 1991, U.S. imports of fresh Canadian salmon increased by over 30 percent (see Table 5 in Appendix A). It is possible, however, that salmon from Chile and other countries with lower production costs could challenge Canada's dominant position in the U.S. salmon market.

Despite these impediments to growth, Canada's farmed salmon industry has shown determination and resiliency in meeting various challenges. Salmon aquaculture in British Columbia has grown in a rapid, almost "gold-rush" fashion, whereas Atlantic Canada's salmon farming industry has developed at a more conservative pace. Both approaches have encountered problems and both have succeeded, although to a lesser degree than was anticipated only a few years ago when Canadian sources confidently projected salmon production exceeding 30,000 t by the early 1990s.

C. The 1989 price decline

During 1987 and the first half of 1988, the Norwegian price for Atlantic salmon was fairly stable at US$10.50-11.00/kg. However, by July 1988, the price began to fall, and by December 1988, it had dropped below US$8.80/kg. The price finally stabilized at US$7.40/kg in July of 1989, amounting to a decline of about 35 percent. The prices for Atlantic salmon harvested in Atlantic Canada were very close

to the Norwegian prices during this period, but species of Pacific salmon traded at lower prices. The B.C. price for chinook salmon, for example, traded at just under US$9.90/kg in the fall of 1987. After the volumes of farmed salmon increased significantly in August of 1988, prices fell but then remained stable during the winter of 1988-89, at US$7.90-8.25/kg. In April of 1989, the B.C. price dropped even more sharply. By July, chinook salmon was trading at US$5.50/kg. The B.C. price declined approximately 35 percent in less than four months; it dropped 45 percent from the previous spring's prices of US$9.90/kg.[14]

1. Supply factors

The world price for farmed salmon declined significantly during 1989 mainly because of the sharp increase in world supply. From 1985 to 1989, the total number of countries producing over 2,000 t of farmed salmon grew from just three to ten. By 1989, the total world production of farmed salmon increased to 213,000 t, nearly five times the 1985 production level of 52,000 tons. Prior to 1989, industry analysts concluded that because the world production of farmed salmon was growing rapidly, eventually the premium prices producers were getting for their product would be significantly reduced. The increasing number of producing regions was augmenting competition and product demand was stabilizing. However, few analysts forecasted that world production would rise to over 200,000 t in 1989. Forecasts made in 1987 predicted that world production would not reach over 200,000 t until 1990, so the price decrease was not expected to occur until 1990. Therefore, when world production amounted to 209,510 t in 1989, many companies were unprepared to deal with the 35 percent drop in price that followed.[15]

At the time of the price collapse, the majority of producing companies had only been established within the previous five years. Since it takes at least two years before any return on investment is realized, most were still carrying significant debt loads and needed another year of good prices in order to prepare for the depressed prices anticipated in 1990. Thus, the drop in prices led to a reorganization of the salmon farming industry worldwide, particularly in B.C., Scotland and Norway.[16]

Until 1989, the world market for salmon was a seller's market. Because of the limited availability of the product, producers were able to get premium prices for farmed salmon. The demand for farmed salmon exceeded supply, which resulted in the high prices of 1987 and early 1988. However, the increase in world supply, combined with the fact that new producers were providing high quality salmon, created an extremely competitive world salmon market. With the rise in competition, the market became a buyer's market. Consumers found themselves with a wide variety of suppliers to choose from and were able to demand significantly reduced prices for salmon. The problem was exacerbated in British Columbia. As the supply of farmed salmon expanded, individual producers began acting as sales agents rather than coordinating production with a sales and marketing cooperative or an existing large processing company. Thus, buyers were able to take even greater advantage of the increased supply to decrease the price of B.C. farmed salmon. World prices for salmon began a downward trend in the summer of 1988 which continued into 1989 as the producing countries began to increase their production levels tremendously.[17]

The decline in price in North America can also be attributed to the structure of the salmon farming industry. The traditional seafood marketing and distributing system has operated with middlemen coordinating production decisions of producers and the purchase decision of consumers. Therefore, when the prices received by salmon farmers dropped 30 percent, the retail price of farmed salmon to consumers did not drop correspondingly; the multi-layered distribution system that exists for the fresh/frozen fish market absorbed much of the reduced price. In this situation, the producer loses because the reduced prices lower his profit margin, but product consumption does not increase. It takes time for consumer prices to adjust completely due to imperfect price information and inefficient functioning of the market.[18]

2. Demand factors

Several demand factors also influenced the 1989 drop in world prices. These factors included: (1) the 1988 drop in Japanese salmon consumption, (2) the high prices of 1988, (3) negative publicity on ocean pollution, and (4) competition from other protein groups.[19]

Decreased Japanese salmon consumption -- Japan, with an annual salmon consumption over 300,000t, is the single most important salmon market in the world. However, in the 1988-89 period, Japanese consumption of salmon fell significantly because of the Emperor Hirohito's illness. To demonstrate

honor and respect for their Emperor, the Japanese people reduced their consumption of luxury food items, which included salmon, until one month after his death in January 1989. The decreased consumption resulted in increased inventories of frozen salmon in the United States and Canada, as well as in Japan, which contributed to the decline in prices for all salmon products in 1989.

High 1988 prices -- In 1988, both Japanese and European buyers paid record prices for salmon imports. However, they were not willing to purchase salmon at the same price level in 1989.

Negative publicity on ocean pollution -- There was a large amount of negative press that focused on ocean dumping in 1988. This bad publicity undoubtedly contributed to the lowered per capita consumption of salmon, which, in turn, depressed the price of salmon worldwide.

Competition from other protein groups -- There has been a significant increase in competition from other protein groups, each representing multi-faceted, billion dollar industries and commanding considerable economic and political leverage. In an attempt to increase their respective total market shares, the groups are investing in several areas which include generic and brand name marketing campaigns, expanded research and development into the health and nutritional attributes of their product, product diversification, and utilization of political and media contacts to ensure their protein group maintains a high profile. The seafood industry is not considered to be a significant competitor because it holds only a small percentage share of total per capita consumption of protein. Therefore, the industry as a whole has difficulty withstanding the intense marketing campaigns of the other groups.

II. BRITISH COLUMBIA

A. General

British Columbia has 27,000 kilometers of coastline and sheltered inlets which provide an almost unlimited supply of sites which are suitable for fish farming. Selecting a site, however, depends on several factors such as proximity to markets and access to transportation routes, availability and costs of feed and other supplies, proximity to sources of pollution, and the level of flushing action to maintain high oxygen concentrations and remove fish wastes. In terms of sites and water quality, the environment in B.C. is better than that in Norway. Norway's coastal waters are relatively shallow in comparison to B.C., and the tidal flux on the open waters of the North Sea is significantly less than the tides in the Pacific Northwest. These factors contribute to pollution problems in Norway as water exchange is more restricted than in B.C.[20]

The Sunshine Coast (Sechelt) region was the original focal point for the industry's growth, but development subsequently spread to the Campbell River, Tofino, and the west coast and northern areas of Vancouver Island. As salmon farming experience has increased, it has become apparent that some areas are less suitable for culture than originally believed. The Sechelt area, for example, which saw the early expansion of the industry, has encountered serious problems from algae blooms. Therefore, more and more sites are being located on the East and West Coasts of Vancouver Island (see map).[21] As of January 1990, 138 salmon farming sites (10 leases and 128 licenses) were on Vancouver Island, 68 were on the Sunshine Coast, and only 7 were in the Prince Rupert North Coast region.[22]

Beginning in 1984, there was a surge in the number of operating salmon farms and applications for operating licenses in the province. In just four years, the total number of operating sites increased 15-fold, rising from 10 in 1984 to 150 in 1988. The number of companies involved in salmon aquaculture also increased during this time, reaching 105 in 1988. In 1989, however, the number of companies and sites began to decline, as many salmon farming companies succumbed to receivership.[23] The total amount of salmon farming companies was reduced to 80 in 1989 and to 50 in 1990, while the number of operating sites fell to 138 in 1989 and to 118 in 1990. The reduction in sites has been less drastic than that in companies, because some companies have expanded operations to new sites.[24] As of January 1990, there were 213 approved salmon tenures, which included 203 licenses and 10 leases, and 33 investigative permits issued by the Provincial Government of British Columbia. In addition, 60 new applications and amendments of development plans were being reviewed by the B.C. Ministry of Agriculture and Fisheries.

Salmon farming is the largest revenue producer in British Columbia's aquaculture industry. In 1987, salmon farming comprised 80 percent of B.C.'s total

Figure 3.--Map of British Columbia

aquaculture production value, accounting for almost C$13 million of the C$16 million in total earnings. Farmed salmon production in 1989 was valued at C$85 million, approximately 95 percent of total aquaculture production in British Columbia. In 1991, the value of the industry increased to C$135 million (see Table 1 in Appendix F.1).

B. Historical development

1. Early efforts

The first commercial salmon farming in British Columbia began in the early 1970s with initial efforts aimed at rearing pan-sized coho and chinook. The first farm (a private venture which began operating in 1972), and four farms established in 1975 obtained surplus eggs from a salmon hatchery owned by DFO.[25] Many of the ventures, however, were unsuccessful on a commercial basis because of high mortalities, inadequate financing and technical difficulties which included: inadequate broodstock, poor site selection, poor husbandry techniques, poor diets and lack of understanding of major diseases such as bacterial kidney disease (BKD), furunculosis and vibrio. Farmers experienced the full range of problems involved in bringing a new species into cultivation.[26]

Progress in the B.C. salmon farming industry remained slow at first, producing only small quantities of farmed salmon and attracting little interest. The few farms that were operating experienced a number of setbacks. In addition to low survival rates, growth rates were often lower than expected. Profits were also lower than anticipated, because farms focused on the pan-sized market that proved to be less successful than the larger size fish market. As mentioned above, firms also faced under-capitalization and difficulty in obtaining financing. In fact, B.C.'s largest aquaculture firm, Apex Bio Resources Limited, collapsed in January 1982, in part because of the problems it faced acquiring capital.[27]

Fortunately, the early efforts at farming Pacific salmon provided the foundation necessary for the ensuing development of the industry in the mid-1980s. The experience indicated that coho and chinook were the two species of Pacific salmon best suited for cage culture. In addition, DFO's participation contributed valuable expertise to the commercial hatchery production of Pacific salmon smolts.[28]

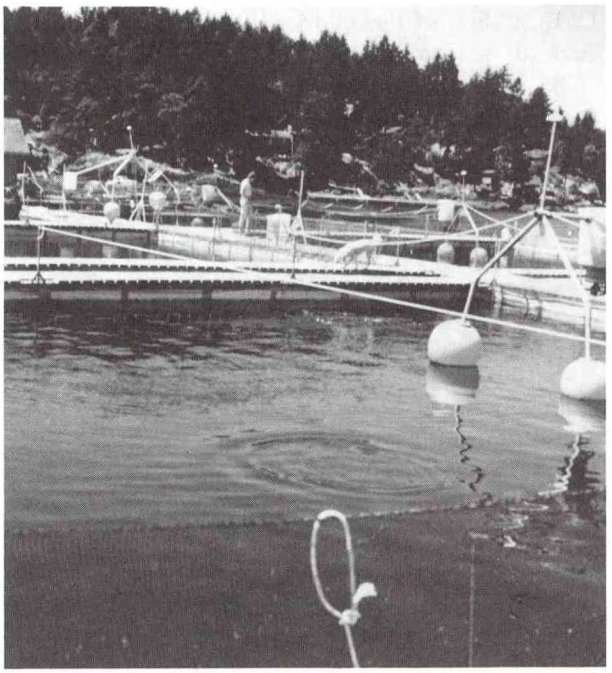

Figure 4.--Salmon farm on Vancouver Island in British Columbia.

2. The expansion period

The successes of the European salmon farming industry in the early 1980s fueled the expansion of production in B.C. The first significant exports of European farmed salmon to North America began in the winter of 1979-80. It soon became apparent that a large market for fresh salmon was developing in the United States which stimulated investment and renewed efforts at salmon farming in B.C.[29]

Norwegian fish farmers began to invest in British Columbia in the mid-1980s. With the increased interest in B.C. salmon culture, the number of operating salmon farm sites increased from 10 in 1984 to 37 in 1985, 69 in 1986, 118 in 1987, and 150 in 1988. Cultured Pacific salmon production increased by over 6,000 percent from 1984 to 1988, as production soared from 107 t in 1984 to 6,590 t in 1988. The industry developed most rapidly from 1986 to 1988. The same two-year period, however, was also marked by disappointing results with neutered coho, lack of knowledge about disease treatments, shortages of qualified labor, and conflicts with environmental groups and the wild fishery. Moreover, by 1989, the industry faced a multiplicity of sellers, which led, in part, to its subsequent restructuring. The increased number of suppliers created an inefficient industry, for individual farmers did not coordinate production and thus flooded the market. The price of B.C. farmed salmon dropped well below that of Norway's during this time because of the intense competition between B.C. producers trying to sell to a limited number of prospective buyers in Vancouver and Seattle. Furthermore, because many companies were extremely vulnerable to the 1989 price collapse as a result of accumulated debt, the reorganization process was accelerated. Within less than two years, the number of companies dropped substantially; only about two-thirds of the companies operating in 1988 still remained in 1990.[30]

3. Restructuring of the industry

Since 1988, ownership of salmon farms in British Columbia became increasingly concentrated in the hands of a small number of large corporations. Nine companies, or approximately 18 percent of the total number of companies, produced about 70 percent of the industry's total production in 1990.[31] This phenomenon is due partly to the fact that many entrepreneurs have been unable to meet the high demand for working capital during the start-up years of salmon farming before there is revenue from sales. Therefore, it is the larger companies that are able to proceed with buying or constructing new farm sites. Established firms in other sectors of the seafood industry are also realizing the potential for aquaculture to complement their existing business profitably.[32] The degree of vertical integration in the B.C. industry has increased tremendously as feed companies, such as EWOS Canada Ltd., have integrated forward and major fish processing companies, such as B.C. Packers Ltd., have integrated backwards into salmon farming. As of June 1990, all of the large B.C. firms had their own hatcheries, five had their own processing plants, and four were marketing their own fish. The level of integration is expected to continue to increase in the future.[33]

There is also a trend towards greater concentration in selling, similar to the one occurring in production. The large, vertically-integrated fish processing companies are increasing their sales of farmed salmon all over the North American continent. For example, B.C. Packers Ltd., in addition to having its own hatchery and grow-out sites, has concluded marketing arrangements with other companies. J.S. McMillan Fisheries Ltd. also has marketing arrangements with two of the largest producers and several other companies. Other companies with integrated marketing programs include Pacific Aqua Foods Ltd. (a subsidiary of National Sea Products Ltd.), and Sea Farm Canada (a

joint venture between Sea Farm U.S.A. and Canada Packers Ltd.), which also has operations in New Brunswick. Furthermore, a sales and marketing company called Sea Prime Seafood Ltd. was recently formed by a Finnish-based group of companies, whose subsidiaries include the major feed company EWOS Canada Ltd., and a large salmon farming company, Consolidated General Sea Harvest Ltd. The company will be responsible for selling the production from Consolidated General Sea Harvest Ltd. and other B.C. salmon farming companies.[34]

After the period of rapid expansion from 1986 to 1988, reorganization of the B.C. salmon culture industry was not a surprise; rather, it was expected. Furthermore, although the number of operating companies declined significantly due to mergers and acquisitions from 1989 to 1990, the number of operating sites was never expected to decrease by the same degree. It was assumed that the companies that evolved from the restructuring would expand their operations to new sites.[35] As stated in a 1990 DFO publication entitled *Current Developments in World Salmon Markets: Implications for the Canadian Salmon Farming Industry*:

The consolidation is seen as a redistribution of assets within the industry as other larger players become more involved and smaller operations are consolidated. This will result in fewer companies controlling larger shares in industry production and will increase the operational efficiency of the industry as a whole.[36]

C. Production

1. Production totals and forecasts

In the years immediately following the 1986-88 expansion period, actual farmed salmon production in B.C. was consistently less than the forecasted totals. The industry continued to grow significantly, but not to the degree once believed possible. During the industry's rapid expansion, forecasts suggested that B.C. production would reach 14,500 t by 1989 and 20,000 t by 1990. However, farmed salmon production in 1989 was 15 percent lower than the amount forecasted, totalling only 12,400 tons. After the 1989 results were tabulated, the earlier forecast of 20,000 t for 1990 was reduced 25 percent to 15,000 tons.[37] Nevertheless, the final total for 1990 fell short, reaching only 13,500 tons.[38] In 1989, production was actually close to target throughout the first three quarters of the year, but it declined significantly in the fourth quarter because of accelerated summer harvests and plankton blooms. Industry restructuring, including company consolidation and receiverships, can be blamed for the shortfall of production in 1990.[39]

The B.C. Salmon Farmers Association estimates 1991 farmed salmon production to be approximately 18,000 t and is forecasting that production in 1992 will stabilize around 18,700 tons. The 1991 production was actually 9 percent over the forecast of 16,500 tons. The increase was due primarily to better than expected survival of chinook salmon and unforecasted harvests of chinook salmon as

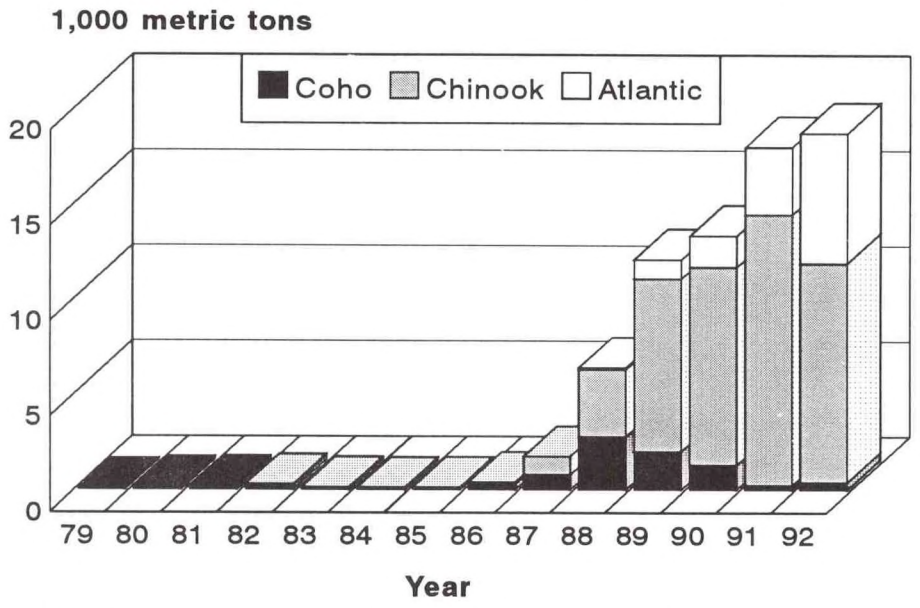

Figure 5.--B.C. Farmed salmon production by species, 1976-91 with projections for 1992.

companies decided to reduce their inventories for management purposes.[40]

2. Species breakdown

Production in British Columbia focuses on chinook, coho and Atlantic salmon. Unlike salmon farmers in Scotland and Norway who only produce Atlantic salmon, B.C. farmers have alternative species options. Chinook and coho, because they are native species, were initially considered the most suitable for farming in B.C. waters. Eggs and broodstock for rearing chinook and coho were more readily available, particularly from the hatcheries associated with the wild salmon enhancement program. Additionally, DFO adopted a restrictive attitude towards the importation of Atlantic salmon eggs to avoid interference with wild Pacific stocks, a stance which inhibited the production growth of Atlantic salmon in British Columbia.[41]

Chinook salmon is currently the species most favorably regarded by B.C. growers because of its late maturation (3-4 years), easy smolt production, and the premium prices it receives in comparison with coho in the North American market. The production of chinook was limited when the industry first began expanding in the mid-1980s because of the low availability of eggs. However, private broodstock programs were able to successfully lift this constraint so that, since 1987, chinook production has exceeded coho production.[42]

There have been problems with rearing coho because of premature maturity (jacking) which affects growth and quality. Coho normally mature after 18 months in sea cages, but they are not ordinarily large enough to sell in the second spring before wild salmon become available. Thus, they usually receive less favorable prices, because, by the time the wild season ends, coho are maturing and darkening. The Chilean industry, however, which also farms coho and competes with B.C. coho farmers, has not experienced the same difficulties, creating another marketing problem for B.C. coho. It has been suggested that these particular problems are the result of over-rapid expansion of the coho industry, but better selection during the freshwater stage and better timing of release into sea cages will lead to improvements.[43]

Atlantic salmon, first introduced into B.C. in 1985, offer advantages over chinook and coho, as they adapt more easily to domestication.[44] Although Atlantic salmon have a long freshwater stage, they grow quickly in sea cages under the all year-round growing conditions of the West Coast, and thus, they are in profitable size ranges throughout their second year at sea. Moreover, the higher prices achieved by European and East Coast Atlantic salmon on the world market are attractive to producers. Atlantic salmon production in B.C. is supplied with small quantities of eggs from imports and from growing domestic broodstock programs. However, the restrictions on the supplies of eggs will continue to limit total production of Atlantic salmon in the future, despite the species' advantages over Pacific salmon.[45]

The DFO is investigating the suitability of pink, chum and sockeye salmon for farming in British Columbia. With the existing knowledge, however, it appears that such culture may not be commercially viable because of high losses during the sea water stage.[46]

As the farmed salmon industry in British Columbia has expanded, the composition of species in the production totals has changed significantly. When the first ventures were undertaken in the 1970s, coho was the species of choice; chinook was not even farmed commercially until the early 1980s. However, during the 1986-88 expansion period, chinook overtook coho as the species constituting the highest percentage of production. The production of Atlantic salmon was negligible until 1988, but it has now also overtaken coho production. In 1991, chinook salmon accounted for 79 percent of total production, Atlantic salmon made up 20 percent and coho comprised only 1 percent (see Table 3 in Appendix F.1).[47]

Whether Atlantic salmon becomes the primary species farmed on Canada's Pacific coast depends on the emergence of the following trends: (1) increased demand for Atlantic salmon on the part of the Japanese in response to an aggressive marketing campaign by Norway, the world's largest producer of farmed Atlantic salmon, and (2) further mixing of the species by B.C. salmon farmers in an attempt to further integrate the marketing of wild and farmed fish in order to maintain a year-round supply of salmon for the U.S. fresh fish market.[48] According to an article entitled "Seafood's Future" in the May/June 1992 issue of *Seafood Business*, the second trend is already materializing.

[A] sign of increasing standardization in farmed salmon comes from British Columbia, where production is shifting to Atlantics, which grow to saleable size much more quickly than traditional

West Coast species. Farmed chinooks will be a thing of the past. Brokers are pleased to see West Coast retailers beginning to run ads on Atlantics to prepare for the upcoming species switch.[49]

3. Smolts

The same trends evident with species farmed in B.C. can also be seen in the production of smolts. Between 1988 and 1989, the total number of seawater smolts increased 50 percent from 19.4 million to 28.9 million. Domestic chinook smolt production more than doubled from 10 million to 23 million, coho smolt production decreased from 6.8 million to 3.1 million, and Atlantic salmon smolt production nearly doubled from 0.7 million to 1.3 million. Thus, in 1989, chinook comprised about 84 percent of the total smolt production, coho made up 11 percent and Atlantic salmon accounted for 5 percent. In 1990, chinook accounted for the same percentage, but coho only comprised 6 percent and Atlantic salmon increased to 10 percent.[50]

D. Government support

Government/industry relations in the B.C. aquaculture industry are notable for the spirit of cooperation that exists. The Provincial Government of British Columbia, with the assistance of the Federal Government of Canada, has established many local and regional assistance programs to assure the safe development of the industry.

In September 1988, the B.C Provincial Government and the DFO signed a *Memorandum of Understanding* which:

1. Clarifies federal and provincial responsibilities,

2. Streamlines application procedures and reduces administrative and legal burdens on the aquaculture industry,

3. Establishes one-step leasing mechanisms for commercial aquaculture ventures, and

4. Sets out a cooperative and coordinated approach for government support of industry, including research and development, training, education, leasing and licensing, and health and stock monitoring.

There are also several programs designed to benefit specific, smaller communities. The Community Economic Development Program (CEDP) in B.C. consists of 28 projects established in cooperation with the DFO's Salmonid Enhancement Program. The aim of the program is to increase the population of salmon while fostering local employment. Through the CEDP, Canadians receive training and employment while enhancing the growth potential of the salmon stock. A primary example of CEDP initiative is a small salmon hatchery started in Fort Babine, B.C., where unemployment was high. The salmon hatchery now produces over 7,000 individual coho and 2,500 chinook annually, providing a small number of permanent jobs as well as numerous seasonal positions.[51]

E. The B.C. Salmon Farmers Association

The British Columbia Salmon Farmers Association (BCSFA) is an industry-sponsored producers' association that was incorporated in 1984 under the Societies Act of British Columbia. It was formed to provide the developing industry with an equitable means of allocating surplus chinook and coho eggs from the federal government's Salmon Enhancement Program to prospective salmon farmers. The BCSFA began with nine members but now represents over 95 percent of all Pacific salmon farmers; it has a Board of Directors and a full-time staff which implement the policies developed by the Board. The BCSFA was first established with the major objectives of maximizing the financial returns to salmon farmers, promoting the production of a quality product, and setting and maintaining standards to ensure the safe development of the industry. In 1987, the BCSFA expanded its services to include communications, marketing, and research. An expanded membership program also now includes all major producers as well as suppliers to the salmon farming industry.[52] (Please refer to Appendix F.3 for a current BCSFA membership list.)

The BCSFA has introduced several programs to assist salmon farmers. These programs include: egg allocation, broodstock development, disease screening, marketing studies, and education. In May 1989, the Government of British Columbia announced the formation of the British Columbia Aquaculture Research and Development Council (BCARDC). The province's first privately funded salmon research farm, the Ewos Pacific Research Farm was opened on Denman Island on June 16, 1989. This C$1.5 million facility is responsible for examining nutrition, health, and feeding efficiency at the 20-pen farm and its laboratory.[53]

III. ATLANTIC CANADA

A. General

The salmon farming industry in Atlantic Canada is concentrated in the Bay of Fundy in New Brunswick (N.B.) and to a lesser extent in Nova Scotia (N.S.). Salmon farming is also being attempted in Newfoundland, as well as in land-based/indoor facilities in Quebec and Prince Edward Island (P.E.I.). Atlantic Canada actually outproduced the B.C. farmed salmon industry in terms of value from 1984 to 1988. Farmed salmon production in Atlantic Canada was valued at over C$43 million in 1988 and accounted for approximately 80 percent of total aquaculture earnings for the region. By 1990, the value of farmed salmon in Atlantic Canada increased to over C$75 million.

There are approximately 60 salmon farms currently operating in Atlantic Canada, of which 49 are located in New Brunswick on the Bay of Fundy and 8 are in Nova Scotia. Both Quebec and Prince Edward Island have an indoor facility capable of producing salmon, however, production at the P.E.I. site has been limited to marine rainbow trout for the most part. Newfoundland has 2 commercial salmon farms located in the Bay d'Espoir in the southern part of the province (see map).

B. Historical development

The first attempts to grow salmon in sea cages in Atlantic Canada were undertaken in Nova Scotia in 1969 and in New Brunswick in the early 1970s. They were unsuccessful, however, because of extreme water temperatures in the winter. The first successful effort was conducted in the waters off Lord's Cove in Deer Island, N.B., beginning in 1978. An experimental sea cage operation with 2,000 salmon smolts was undertaken there by the St. Andrew's Biological Station. Financial assistance for the project was provided by DFO and a local marine consulting company, which, in 1979, sold 6 t of the fresh salmon harvested from the endeavor.[54]

Salmon farming began in the early 1980s, but it was not until Stolt-Nielson A/S of Norway and Canada Packers established a C$3.0 million salmon smolt hatchery near St. George in New Brunswick in 1984 that salmon farming began in earnest. The new company, Sea Farm New Brunswick (now called Stolt

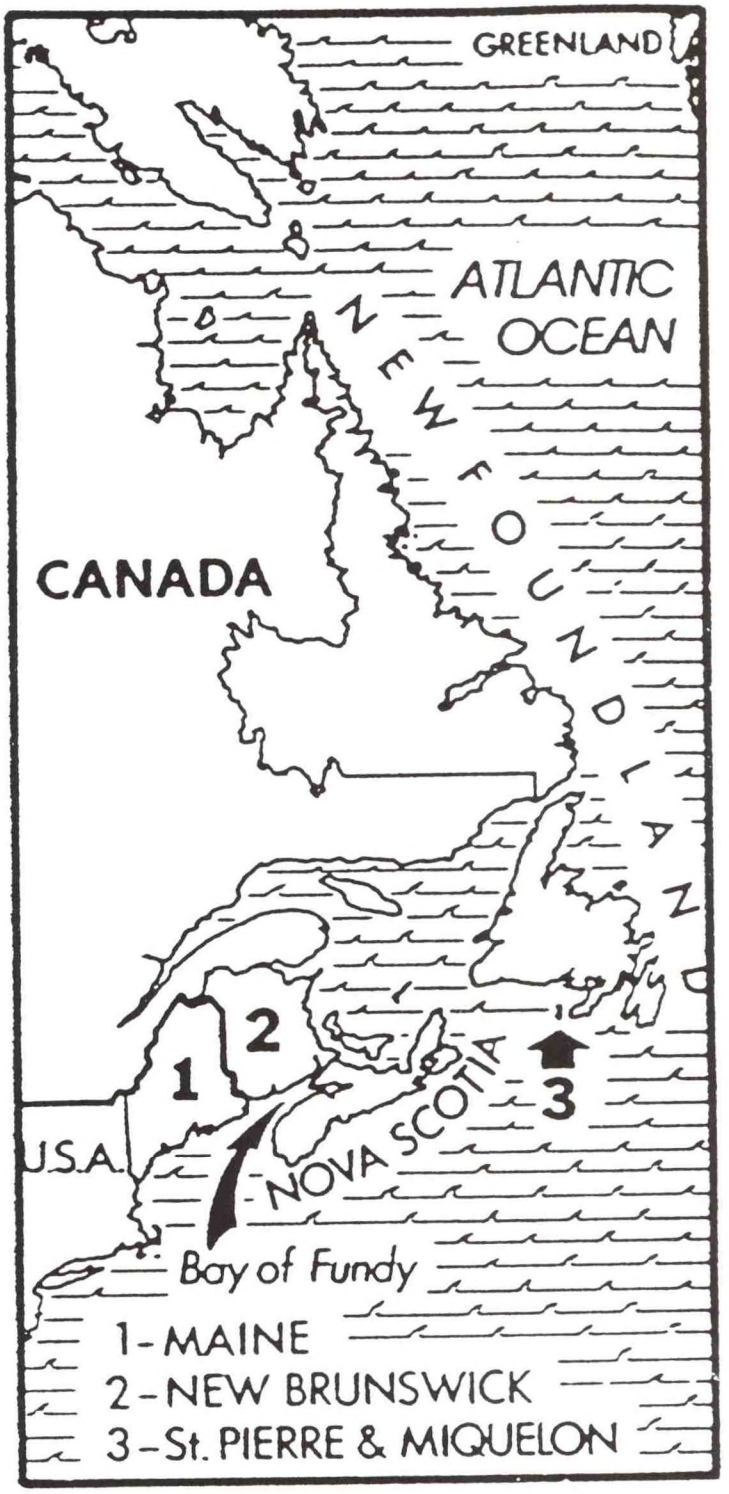

Figure 6.--Map of Atlantic Canada

Sea Farm Ltd.), built a hatchery capable of producing almost 900,000 smolts annually when at full production. Sea Farm Canada also built a 200,000 smolt facility near Sussex in 1986 and opened a fry-smolt grow-out facility near south Oromocto Lake in 1987 at a cost of C$2.5 million. Connors Brothers Ltd., a large fish processing company, followed Sea Farm's lead and got into the aquaculture business in the mid-1980s as well. It started a farm in Deer Island in 1985 and then began constructing a 800,000 smolt hatchery at Lake Utopia in 1986. Connors Brothers also produces a moist salmon feed that is used by the majority of the farms.[55]

The Atlantic Salmonid Demonstration and Development Farm (SDDF), located at Lime Kiln Bay in New Brunswick, was established in 1986 with funding from the Fisheries Subsidiary Agreement of the Canada-New Brunswick Economic and Regional Development Agreement. SDDF is run by an advisory committee of federal, provincial and industrial representatives. Salmon farmers in Atlantic Canada benefit from the research conducted at the center, as SDDF's purpose is to facilitate the transfer of salmonid sea cage culture technology to the aquaculture industry in the Bay of Fundy. Emphasis has been placed on fish nutrition, salmon genetics research, and the monitoring of commercial salmon cages.

C. Production

The first significant harvest of farmed Atlantic salmon in Eastern Canada was in 1986 when approximately 647 t, valued at over C$8 million, went to market. In 5 years, however, the harvest increased 15-fold. The 1990 harvest of 7,925 t resulted in sales of over C$43 million. Farmed salmon production for 1991 is estimated at 9,000 t, and, according to projections, harvests are expected to continue increasing. In fact, the New Brunswick Salmon Growers Association is forecasting harvests of about 10,000 t (valued at C$82.5 million) for 1992 and 13,000 t (valued at C$100.1 million) by 1995 for the province of New Brunswick alone. Some industry forecasts are projecting that total farmed salmon production for Atlantic Canada will reach 15,500 t by 1995.[56]

D. Salmon culture in New Brunswick

New Brunswick is the largest producer of aquaculture products in the Maritime Provinces. In 1989, the province's 12 smolt production sites produced 2.1 million smolts, and 49 salmon farms harvested 4,500 t of Atlantic salmon worth C$42 million. The same number of farms harvested 7,500 t, valued at C$74.3 million, in 1990 and approximately 9,000 t, valued at C$79.9 million, in 1991. The aquaculture harvest in New Brunswick is expected to generate over C$100 million by 1995.

The New Brunswick industry is dominated by many small farms that produce an average of 200 t annually and two large firms, Connors Brothers and Stolt Sea Farm Ltd. There are currently 54 licensed farms in the province, of which 49 or 50 are operational. The lower Bay of Fundy, from Deer

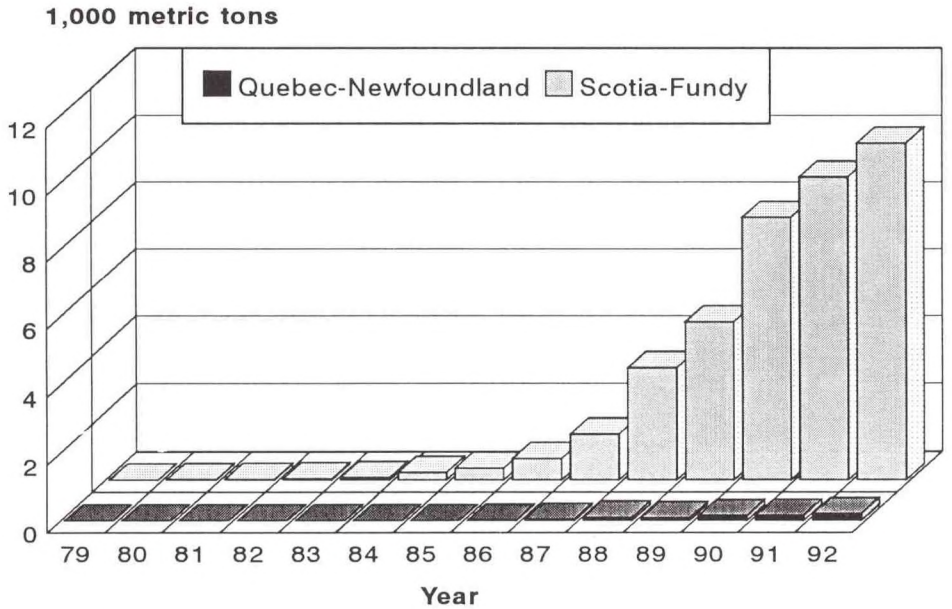

Figure 7.--Atlantic Canada. Farmed salmon production by province, 1979-92.

Island to Eastport, is dotted with small islands and sheltered bays which are ideal for salmon farming. Upwellings keep water temperatures above freezing in the winter, and huge tides provide sufficient flushing action to remove waste products from the cages, yield high oxygenation and prevent massive algae blooms.[57]

On February 27, 1988, the Provincial government implemented the *New Brunswick Aquaculture Act*. The Provincial Department of Fisheries and Aquaculture was entrusted with the sole responsibility for the promotion of aquaculture, including development of new species. Previously, control of aquaculture was divided among different agencies of the provincial government, including those dealing with fisheries, natural resources, energy, and technology. There is a cooperation between the provincial government, the salmon farming industry in New Brunswick, the academic community and the private sector. Salmon farming in New Brunswick, unlike that in B.C., has grown at a very orderly pace due, in part, to the cautious approach taken by provincial authorities. The New Brunswick Government placed a moratorium on the issuance of farming licenses in 1986, to ensure that the government had time to integrate aquaculture with the traditional fisheries. The moratorium was lifted in the fall of 1988 as projected, but the provincial Department of Fisheries and Aquaculture is careful about awarding licenses for salmon farms. The net result is that no salmon farms have failed in New Brunswick. Many traditional fishermen in the Bay of Fundy have branched into salmon farming as an additional source of income to supplement a fishery which is not thriving.[58]

The three major players in New Brunswick's salmon farming industry are Connors Brothers, Stolt Sea Farm Ltd., and Atlantic Silver.[59]

Connors Brothers -- Owned by George Weston Ltd., an C$11 billion food conglomerate, this firm is the leading sardine canner in North America. It entered into salmon farming after noticing several small salmon farms being established in the area around its canneries. Connors Brothers opened a farm near its Deer Island cannery in 1985 and then began constructing a 800,000 smolt hatchery at Lake Utopia in 1986. In addition, Connors is the largest supplier of fish food to New Brunswick's salmon farming industry and markets salmon from other farmers, making it a totally integrated salmon farming company.

Stolt Sea Farm Ltd. -- This firm, originally called Sea Farm New Brunswick and later Sea Farm Canada, Inc., began as a joint venture between Norway's Sea Farm A/S and Canada Packers, a C$3 billion food distribution company in 1984. Sea Farm, which began by selling smolts in Norway and Scotland, now sells smolts and raises salmon in both Canada and the United States. Because Canada Packers is no longer involved in the project, the company is now called Stolt Sea Farm Ltd. Stolt presently operates 3 hatcheries, 3 marine farms, and 2 processing plants: one in St. George, N.B., and the other in Maine. Stolt is highly integrated in the salmon farming industry; it only lacks a feed plant in its operations.

Atlantic Silver -- This organization was established in 1985 as a marketing cooperative. It is run by nine small 100-200 t farms that participate in the industry in New Brunswick. The cooperative markets Atlantic salmon for its members for a commission of 1-2 percent of the gross sales price. The fish are sold under the Atlantic Silver label to establish brand loyalty which will be based on consistently high quality that a consortium can supply.

E. Salmon culture in Nova Scotia

The Atlantic salmon aquaculture industry in Nova Scotia is much smaller than that in New Brunswick. In addition, a large portion of the sites in Nova Scotia actually grow a combination of steelhead and salmon. In 1990, there were 8 hatcheries and 18 operating sites, 8 farming a combination of steelhead and salmon and 10 farming only steelhead. The farms are located primarily located in Cape Breton and along the Eastern Shore of the province.[60] There is also one land-based farm located in Glace Bay. Nova Aqua Smolt Farm, the largest indoor fish farm in the world, was established as a joint venture between Seacoast Fish Farming Ltd. and Norsk Aqua A/S of Bergen, Norway. Nova Aqua, now known as Golden Eagle, has several subsidiaries involved in salmon aquaculture.[61]

Total farmed salmon production in Nova Scotia amounted to 37 t in 1987 and then decreased to 27 t in 1988. Production increased significantly to 145 t in 1989, but was lower than initially anticipated. Forecasted production was not met because there were mortality problems at some of the farms, and some of the salmon farmers decided to hold their stocks because of the lower than expected prices that occurred in 1989.[62] DFO estimated Nova Scotia's harvest to be 284 t in 1990.

F. Salmon culture in Newfoundland

Salmon aquaculture in Newfoundland is still considered to be in an experimental stage. There are, however, two private operations, a provincial demonstration farm, and a pair of experimental facilities operated by development associations located in the Bay d'Espoir in southern Newfoundland. The two facilities operated by the development associations are involved in experimentation, technological development, and evaluation. The private farms were opened in 1987 and were expected to have their first harvest in the fall of 1988. Unfortunately, the commercial industry suffered a major setback in 1988 when about 450,000 farmed salmon, smolts, and market fish were destroyed. The reason for this was the low marketability that resulted from poor quality of the original broodstock.[63] The industry, however, did begin to recover; by 1989, the one hatchery in operation in Newfoundland was attempting to grow smolts again using eggs from the Baie des Chaleurs in Quebec and New Brunswick's Bay of Fundy.[64]

The industry is expected to expand in the coming years. There were ten applications for new licenses in 1989 alone. A *Memorandum of Understanding* was signed in February 1988, between Federal and Provincial Fishery Ministers. It gave the Newfoundland Department of Fisheries the sole responsibility for licensing fish aquaculture sites and clarified federal and provincial roles.[65]

One production problem facing Newfoundland growers continues to be the availability of smolts. Newfoundland does not allow the importation of smolts into the province, and the province's salmon hatchery has a capacity of only approximately 200,000 smolts. The Newfoundland Provincial Government provides smolts to farms, but hopes to decrease that role. Other constraints include ice cover and cold water temperatures which prevent raising salmon in outdoor facilities. Research has been conducted into the possibility of raising salmon in the colder northern water of Newfoundland. The *Green Bay Development Association* is currently developing an overwintering cage for salmon which would enable fish to be raised in these waters. It received funding from the provincial government to conduct tests on a cage made of two chambers, one for heating the water and the other for holding fish. This would provide fish year round for the association's customers.[66]

G. Salmon culture in P.E.I.

Attempts at salmon farming in Prince Edward Island have been limited to a land-based facility because of cold water temperatures and icy conditions in the winter. The province has one large indoor salmon and trout growing facility in Georgetown. The farm was originally built by Norwegian and Canadian investors with financial assistance from governments which approved a loan guarantee and a low interest rate loan. The initial investor experienced financial troubles in late 1988, so the farm was operated by the receiver until the summer of 1989 when it was sold at a loss to a third party. The farm was put in receivership for a second time in February 1990.[67] Production at the P.E.I. site had been limited to steelhead until 1990, when the farm reportedly produced 1 t of Atlantic salmon.[68]

H. Salmon culture in Quebec

Salmon farming in Quebec has been constrained by severe winter water temperatures and ice. The only salmon farm operating in Quebec is a land-based tank facility located at St. Omer on the Baie des Chaleurs in the Gaspé peninsula. The farm which opened in 1985, has been somewhat successful; it produces its own feed as well as its own smolts. Production results were lower than expected in 1989 due to bacterial disease. The farm was anticipating a production level of about 500 t for several years beginning in 1990.[69] However, DFO preliminary statistics report farmed salmon harvests of only 22 t for 1989 and 50 t for 1990.

IV. MARKETS

A. General

Canadian farmed salmon sales, for the most part, are limited to the North American market, including the urban centers of Toronto and Montreal as well as the large U.S. market. Because Canada is the dominant supplier of seafood products to the United States, Canadian farmers enjoy several advantages over their European competitors. These include Canada's familiarity with the U.S. market, as they already have an established market network in the United States. The United States in turn is familiar with Canadian companies, resulting from the long relationship that the two countries have shared.

Canadians also have a cost advantage over European competitors in respect to the U.S. market as they enjoy reduced transportation costs and can take advantage of their ability to supply high-quality, fresh salmon on a consistent basis. Furthermore, one significant result of the oversupply that occurred in 1989 was the decision by the major international producers to increase marketing efforts rather than make drastic cuts in production. Because much of the marketing effort is being directed at the development of increased consumption in the United States, Canada should benefit greatly.[70]

Canadian fish farmers see the U.S. market growing by 30,000 t per year, stimulated by a new generation of health conscious consumers who enjoy low-calorie, low-cholesterol, fresh salmon. The Free Trade Agreement between Canada and the United States has helped create new market opportunities in the United States for Canadian farmed salmon. Farm raised salmon from British Columbia receive premium prices when wild salmon are not available, so B.C. farmers plan to market their fish November through May before the wild season opens. Salmon farmed in Atlantic Canada, on the other hand, do not have to compete with a wild salmon fishery, therefore farmers market their salmon 12 months a year.

Although Canada's best market is the United States, Japan is one of the world's leading importers of salmon, buying high-quality chinook, sockeye, and coho from the wild catch market and increasing amounts of salmon from the farmed market. Between 1983 and 1987, the presence of Norwegian salmon in the Japanese market rose from 134 t to 1,452 tons.[71] Geographically, B.C.'s location with respect to Japan may provide it with an advantage over Norway in terms of transportation costs in the coming years.[72] Norway's dominance of the European salmon market, as well as Norway's proximity to the European market makes it too costly for Canadian farmers to enter that market to any significant extent.

B. Markets for B.C. salmon

B.C. farmed salmon is sold in almost all of the major urban areas of North America. In 1989, about 70 percent of B.C. salmon production (8,700 t) was sold in the United States, of which the West Coast, California in particular, absorbed 40 percent. Other significant markets, however, included New England (Boston), the Mid-Atlantic (New York), and North-East Central (Chicago). Approximately 23 percent of total production (27,000 t) was sold in Canada; the majority went to the local B.C. market, but some was also distributed in Ontario and Quebec. Japan absorbed roughly 8 percent of B.C.'s 1989 production (1,000 t).[73]

C. Markets for Atlantic Canada salmon

Historically much of the salmon grown in Atlantic Canada has gone to markets in central Canada, notably Toronto and Montreal. As production has expanded, however, so too have the markets. Farmed salmon is now shipped in large quantities to the United States. In 1989, approximately 70 percent of salmon farmed in Atlantic Canada was marketed in the United States, 25 percent was sold in Ontario and Quebec, and the remainder was sold locally in the Maritime Provinces.[74] At the present time, Atlantic salmon is sold mainly in fresh whole form; the Atlantic Canada industry has avoided the necessity of freezing salmon which Norwegian and British Columbia producers have had to do because of temporary supply surpluses.[75]

V. OUTLOOK

Competition among salmon producers is certain to remain high. Canadian salmon farmers will have to remain very cost-effective as well as concentrate on marketing their product in an efficient manner. The ability of each farm to survive in the market will depend on its ability to bring relatively low-priced salmon to market. The Canadian industry as a whole will have to maintain the share of the market it now has and work diligently to capture new markets, particularly in Japan.

The salmon farming industries in British Columbia and Atlantic Canada both look strong. Since the price decline in 1989, salmon farmers have taken steps to ensure the continued success of the industry; they have integrated operations and improved their marketing strategies. The change in B.C. has been particularly significant.

The salmon farming industry in British Columbia has undergone considerable structural change since 1989. The period of rationalization has had the effect of removing the uncommitted and consolidating the industry into fewer but larger players. The increased concentration and vertical integration of companies was a necessary

transition in order to successfully compete in the highly competitive world fresh salmon markets of the 1990s.[76]

Demand for farmed salmon should continue to increase as consumers continue to emphasize nutritious, healthy, tasty and low-cost seafood. Increased consumption should result in new value-added forms of salmon. Products such as smoked salmon, marinated salmon, and fresh fillets and portions will develop new markets for farmed salmon.

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ENDNOTES

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Appendix F

Canada

Appendix F.1

Statistics

Table 1.--Canadian farmed salmon harvests, 1979-92.

Year	Atlantic Canada		British Columbia		Salmon harvests	
	Quantity	Value	Quantity	Value	Quantity	Value
	Metric tons	*C$1,000*	*Metric tons*	*C$1,000*	*Metric tons*	*C$1,000*
1979	6	49	41	157	47	206
1980	11	82	157	898	168	980
1981	21	156	176	985	197	1,141
1982	38	315	273	1,136	311	1,451
1983	68	675	128	708	196	1,383
1984	223	2,572	107	702	330	3,274
1985	350	4,197	120	820	470	5,017
1986	647	8,078	391	2,700	1,038	10,778
1987	1,390	18,415	1,739	12,700	3,129	31,115
1988	3,400	43,200	6,405	38,500	9,805	81,700
1989	4,667	43,340	12,083	85,000	16,750	128,340
1990	7,835	74,641	13,332	105,000	21,167	179,641
1991	9,000*	79,912*	17,979*	135,000*	26,979*	214,912*
1992	10,000*p*	NA	18,700*p*	NA	28,700*p*	NA0

Source: Data for Atlantic Canada, 1980-88, and for British Columbia, 1980-85, obtained from *Long Term Production Outlook for the Canadian Aquaculture Industry (1990 Edition)*, Economic and Commercial Analysis Report No. 67. Ottawa: Department of Fisheries and Oceans, July 1990. Atlantic Canada data for 1989-92, as well as statistical adjustments for previous years, obtained from the New Brunswick Salmon Groweres Association. B.C. data for 1986-92 obtained from the B.C. Salmon Farmers Association.

* - *Estimate, p - Projection.*

Table 2.--Canadian salmon farms, 1980-92.

Year	Atlantic Canada			British Columbia	Total Farms
	New Brunswick	*Nova Scotia*	*Quebec/ Newfoundland*		
	Number of Farms				
1980	2	NA	0	NA	2
1981	4	NA	0	4	8
1982	5	NA	0	5	10
1983	5	NA	0	8	13
1984	10	NA	0	10	20
1985	20	NA	1	37	58
1986	28	NA	1	69	98
1987	34	10	3	118	165
1988	34	13	3	150	200
1989	49	8	3	138	198
1990	49	8	3	118	178
1991	49	8	3	130	190
1992	50	8	3	130	191

Source: Statistics for 1980-89 obtained from *Long Term Production Outlook for the Canadian Aquaculture Industry*, Economic and Commercial and Analysis Report No. 13. Ottawa: Department of Fisheries and Oceans, January 1989,and *Long Term Production Outlook for the Canadian Aquaculture Industry (1990 Edition)*, Economic and Commercial Analysis Report No. 67. Ottawa: Department of Fisheries and Oceans, July 1990. Data for 1989-92 obtained from the B.C. Salmon Farmers Association and from a June 1992 cable from U.S. Consulate in Halifax, N.S.

Table 3.--BRITISH COLUMBIA. Farmed salmon harvests, by species, 1976-92.

Year	Salmon harvest, by species			Total	
	Chinook	Coho	Atlantic	Quantity	Value
	Metric Tons				*C$ thousands*
1976	0	NA	0	0	NA
1977	0	NA	0	0	NA
1978	0	NA	0	0	NA
1979	0	41	0	41	157
1980	0	157	0	157	898
1981	0	176	0	176	985
1982	43	230	0	273	1,136
1983	55	73	0	128	708
1984	43	64	0	107	702
1985	54	66	0	120	820
1986	87	304	0	391	2,700
1987	949	790	0	1,739	12,700
1988	3,550	2,775	80	6,405	38,500
1989	9,049	2,021	1,013	12,083	85,000
1990	10,396	1,296	1,640	13,332	105,000
1991	14,245*	211*	3,523*	17,979*	135,000*
1992	11,500*p*	400*p*	6,800*p*	18,700*p*	NA

Source: Production data for 1976-85 obtained from *Fisheries Production Statistics of British Columbia*, 1985 and 1987, Province of British Columbia. The B.C. Salmon Farmers Association supplied the production data and the total value estimates for 1986-92. Total value statistics prior to 1986 taken from *Long Term Production Outlook for the Canadian Aquaculture Industry (1990 Edition)*, Economic and Commercial Analysis Report No. 67 Ottawa: Department of Fisheries and Oceans, July 1990.

* - *Estimate, p - Projection.*

Table 4.--ATLANTIC CANADA. Farmed salmon harvests, by province, 1979-92.

Year	Salmon harvest, by province					Total	
	New Brunswick	Nova Scotia	Newfound-land	Quebec	P.E.I.	Quantity	Value
	Metric Tons						*C$ 1,000*
1979	6	NA	0	0	0	6	49
1980	11	NA	0	0	0	11	82
1981	21	NA	0	0	0	21	156
1982	38	NA	0	0	0	38	315
1983	68	NA	0	0	0	68	675
1984	223	NA	0	0	0	223	2,572
1985	350	NA	0	0	0	350	4,197
1986	636	NA	1	10	0	647	8,078
1987	1,318	37	0	35	0	1,390	18,415
1988	3,273	27	0	100	0	3,400	43,200
1989	4,500	145	0	22	<1	4,667	43,340
1990	7,500	284	0	50	1	7,835	74,641
1991	9,000	NA	NA	NA	NA	9,000	79,912
1992	10,000*p*	NA	NA	NA	NA	10,000*p*	82,500*p*

Source: Statistics for New Brunswick, 1979-92,obtained from the New Brunswick Salmon Growers Association. Production value statistics and Nova Scotia data, 1979-87obtained from *Long Term Production Outlook for the Canadian Aquaculture Industry (1990 Edition)*, Economic and Commercial Analysis Report No. 67 Ottawa: Department of Fisheries and Oceans, July 1990. Data for 1989-90obtained from DFO.
* - *Estimate, p - Projection.*

Table 5.--United States. Imports of salmon from Canada, 1982-91.

Year	Imports			Total	
	Fresh	Frozen	Smoked	Quantity	Value
	Kilograms				*US$1.00*
1982	1,937,297	2,173,199	44,498	4,154,994	18,123,650
1983	1,911,339	2,756,196	41,493	4,709,028	20,256,958
1984	2,522,477	2,542,334	44,070	5,108,881	24,729,604
1985	1,460,941	3,394,976	35,593	4,891,510	22,671,164
1986	2,479,749	5,068,000	93,618	7,641,367	27,764,783
1987	3,854,568	4,689,729	68,457	8,612,754	40,200,307
1988	6,460,005	4,266,773	64,752	10,791,530	64,209,895
1989	20,695,323	5,443,977	151,162	26,290,462	122,919,921
1990	21,637,300	4,433,285	70,813	26,141,398	128,952,689
1991	28,342,239	3,778,731	36,406	32,157,376	159,162,320

Source: U.S. Bureau of the Census.

Table 6.--United States. Imports of fresh salmon from Canada by quantity and month, 1982-91.

Month	Fresh Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	95,290	188,947	189,984	28,647	130,846	92,787	303,245	1,368,746	1,261,275	1,470,563
February	14,692	8,006	61,918	11,436	9,828	60,035	182,242	1,046,567	1,349,265	2,044,257
March	14,563	16,600	12,525	32,800	18,811	57,210	372,148	1,245,225	1,469,035	2,511,555
April	20,087	101,436	13,355	12,846	16,423	230,544	486,994	1,287,620	1,361,197	2,613,991
May	184,709	216,189	145,429	62,754	30,552	60,341	138,800	1,095,531	1,465,680	2,650,348
June	185,040	104,538	157,525	35,378	33,225	172,765	167,743	1,404,827	880,861	2,323,999
July	246,058	306,370	322,204	176,330	390,173	424,154	478,542	2,134,851	2,609,592	2,791,329
August	227,764	205,862	144,958	108,040	386,457	497,176	908,728	5,500,063	4,740,291	3,285,555
September	211,722	237,303	412,210	146,923	238,857	346,252	907,379	1,920,840	1,906,442	1,875,009
October	276,621	234,863	248,089	281,747	339,479	1,081,668	1,269,422	1,546,587	1,926,204	2,748,362
November	80,072	152,191	470,687	393,172	535,496	577,680	781,171	1,004,256	1,473,480	2,356,764
December	380,679	139,034	343,593	170,868	349,602	253,956	463,591	1,140,210	1,193,978	1,670,507
TOTAL	1,937,297	1,911,339	2,522,477	1,460,941	2,479,749	3,854,568	6,460,005	20,695,323	21,637,300	28,342,239

Source: U.S. Bureau of the Census.

Table 7.--United States. Imports of frozen salmon from Canada by quantity and month, 1982-91.

Month	Frozen Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	112,118	172,836	268,242	113,659	536,820	532,942	191,841	317,603	205,052	268,754
February	91,691	200,298	194,472	208,867	322,594	534,371	316,494	249,961	298,135	194,861
March	164,050	184,415	132,962	318,577	553,538	495,146	163,045	359,849	367,297	122,372
April	94,179	189,824	58,163	119,637	215,424	364,357	215,333	206,691	233,457	205,305
May	68,362	162,354	30,116	99,704	81,869	295,323	88,803	235,285	173,946	82,374
June	82,659	20,485	23,564	151,406	275,519	413,402	97,493	249,562	248,975	140,251
July	161,626	167,036	47,334	198,888	343,276	148,745	232,981	310,776	127,945	171,608
August	176,242	254,867	91,374	361,730	607,711	390,046	989,802	1,168,452	636,995	622,301
September	368,750	299,147	738,484	377,644	678,745	469,308	739,103	1,284,602	471,321	439,475
October	385,921	483,662	396,228	417,313	603,061	440,330	472,539	435,465	833,449	521,407
November	270,493	286,375	311,011	532,798	382,034	308,510	294,320	383,686	466,515	673,360
December	197,108	334,897	250,384	494,753	467,409	297,249	465,019	242,045	370,198	336,663
TOTAL	2,173,199	2,756,196	2,542,334	3,394,976	5,068,000	4,689,729	4,266,773	5,443,977	4,433,285	3,778,731

Source: U.S. Bureau of the Census.

Table 8. --United States. Imports of smoked salmon from Canada by quantity and month, 1982-91.

Month	Smoked Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	7,497	714	2,256	610	4,798	3,855	1,564	23,942	9,642	1,802
February	11,161	1,937	2,516	2,793	5,416	742	1,446	9,392	4,926	4,788
March	868	1,785	3,311	1,790	7,198	3,272	3,268	10,062	6,509	5,941
April	2,091	2,614	2,390	4,223	3,573	7,761	5,513	7,416	5,049	2,045
May	1,243	7,003	4,555	8,019	13,967	1,839	4,052	10,172	3,663	1,968
June	956	4,132	1,928	1,399	3,341	3,002	5,381	7,324	505	946
July	9,354	6,399	2,540	4,122	6,964	2,917	5,302	7,017	3,288	4,753
August	1,749	1,504	5,459	3,594	1,082	2,747	6,572	11,059	6,306	2,988
September	2,255	2,687	5,058	943	4,852	10,281	8,366	9,546	4,896	2,853
October	2,486	1,994	5,081	3,232	2,162	11,162	12,372	15,383	5,836	1,193
November	1,951	2,433	4,547	2,946	4,972	15,770	5,121	21,794	18,575	2,762
December	2,887	8,291	4,429	1,922	35,293	5,109	5,795	18,055	1,618	4,367
TOTAL	44,498	41,493	44,070	35,593	93,618	68,457	64,752	151,162	70,813	36,406

Source: U.S. Bureau of the Census.

Table 9.--United States. Imports of fresh salmon from Canada by value and month, 1982-91.

Month	Fresh Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	134,550	374,833	343,496	66,672	182,250	583,607	2,628,307	7,657,668	7,239,333	8,953,513
February	90,826	57,519	417,727	72,226	60,365	338,151	1,551,190	6,058,190	7,686,337	12,370,811
March	97,585	138,383	55,912	230,019	88,400	392,898	2,987,205	8,459,876	8,809,953	15,604,052
April	115,478	577,518	77,174	83,672	93,844	1,768,709	3,667,220	8,192,539	8,073,574	15,628,711
May	1,149,635	1,178,818	1,040,944	423,382	129,356	413,434	917,373	6,747,907	8,656,761	15,341,921
June	926,823	558,871	1,056,975	123,693	162,667	1,068,697	1,205,837	7,523,466	5,188,186	12,858,981
July	1,380,617	1,492,015	1,595,575	929,551	1,829,939	1,872,747	2,505,499	8,165,204	10,291,189	12,490,368
August	753,888	746,677	739,563	455,983	1,284,069	1,953,115	5,589,449	21,206,257	20,739,910	13,314,289
September	727,059	1,015,097	1,694,876	536,645	747,734	1,956,271	5,773,612	7,009,861	9,842,467	9,424,856
October	898,001	533,624	705,378	459,978	962,294	4,847,465	5,438,877	4,794,020	8,020,849	10,666,313
November	138,612	377,323	1,027,035	424,506	552,615	2,563,960	3,861,914	5,183,739	7,562,866	9,599,868
December	301,613	293,164	584,984	214,076	418,472	1,991,723	3,193,299	6,053,548	8,222,936	9,499,347
TOTAL	6,714,687	7,343,842	9,339,639	4,020,403	6,512,005	19,750,777	39,319,782	97,052,275	110,334,361	145,753,030

Source: U.S. Bureau of the Census.

Table 10.--United States. Imports of frozen salmon from Canada by value and month, 1982-91.

Month	Frozen Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	555,037	865,066	1,173,276	784,983	2,089,513	1,313,919	1,289,926	1,687,810	1,077,132	1,094,375
February	422,266	987,798	842,852	1,487,762	1,188,136	1,998,446	1,217,837	1,542,799	1,096,480	804,882
March	950,003	947,279	623,235	1,986,973	1,983,078	1,515,890	666,354	1,549,364	1,158,796	588,451
April	567,169	1,016,152	282,595	637,015	823,835	1,116,051	779,252	1,025,146	779,444	680,305
May	305,089	804,914	164,897	645,047	408,601	779,865	489,277	1,233,878	663,017	249,032
June	419,753	78,008	52,426	1,153,663	997,242	1,323,009	351,206	838,451	893,101	583,025
July	724,129	635,287	272,579	1,174,892	1,592,135	639,151	1,191,329	1,177,207	547,112	529,197
August	861,347	937,268	577,564	2,171,195	2,456,215	1,715,805	6,108,353	4,586,058	2,497,423	2,228,457
September	2,078,201	1,115,997	5,220,539	2,167,339	2,688,744	2,775,713	5,070,681	5,652,682	2,130,970	1,455,097
October	1,860,348	1,974,049	2,772,648	1,886,171	2,499,257	3,082,272	3,102,660	1,648,496	3,525,650	1,897,863
November	1,297,487	1,386,168	1,680,653	2,083,840	1,620,191	1,784,705	1,634,285	1,637,454	1,734,161	1,492,702
December	954,431	1,717,911	1,200,620	2,049,315	2,034,076	1,685,457	2,218,884	1,097,724	1,535,172	1,204,607
TOTAL	10,995,260	12,465,897	14,863,884	18,228,195	20,381,023	19,730,283	24,120,044	23,677,069	17,638,458	12,807,993

Source: U.S. Bureau of the Census.

Table 11.--United States. Imports of smoked salmon from Canada by value and month, 1982-91.

Month	Smoked Imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	54,382	13,079	26,116	11,366	43,325	43,249	16,335	268,246	138,724	27,654
February	71,285	24,736	32,696	35,936	77,672	10,196	19,233	166,683	64,104	64,985
March	11,060	22,913	28,578	23,474	55,854	38,475	38,583	183,207	101,411	112,246
April	29,202	36,091	30,264	45,286	42,616	80,397	82,981	121,333	86,324	40,174
May	16,412	65,316	50,643	66,980	136,308	28,468	52,994	164,253	63,768	35,814
June	14,005	60,608	23,863	17,031	44,577	39,872	71,091	97,341	9,843	18,858
July	76,173	27,710	35,079	53,936	83,596	43,064	70,264	124,086	56,964	66,365
August	24,371	21,323	55,777	45,180	14,458	33,856	60,873	151,635	79,832	32,783
September	22,009	28,023	65,676	15,813	69,011	63,401	87,871	137,919	101,418	47,986
October	27,836	24,505	61,352	36,677	13,145	77,683	144,637	232,308	108,774	30,073
November	27,302	30,216	58,333	41,107	50,086	193,534	52,192	334,093	145,295	49,340
December	39,666	92,699	57,704	29,780	241,107	67,052	73,015	209,473	23,413	75,019
TOTAL	413,703	447,219	526,081	422,566	871,755	719,247	770,069	2,190,577	979,870	601,297

Source: U.S. Bureau of the Census.

Appendix F.2

Industry Associations

Atlantic Canada

Aquaculture Association of Canada
P.O. Box 1987
St. Andrews, New Brunswick
E0G 2X0 Canada
Tel: (506) 529-4766
Fax: (506) 529-4274

Canadian Aquaculture Producers' Council
P.O. Box 1058
Shediac, New Brunswick
E0A 3G0 Canada
Tel: (506) 532-2320
Fax: (506) 532-8568

New Brunswick Salmon Growers Association
R.R. 4, Limekiln Road
St. George, New Brunswick
E0G 2Y0 Canada
Tel: (506) 755-3526
Fax: (506) 755-6237

British Columbia

British Columbia Aquaculture Research and Development Council
Suite 506, 1200 West Pender Street
Vancouver, British Columbia
V6E 2S9 Canada
Tel: (604) 683-3387
Fax: (604) 669-6974

British Columbia Salmon Farmers Association
Suite 506, 1200 West Pender Street
Vancouver, British Columbia
V6E 2S9 Canada
Tel: (604) 682-3077
Fax: (604) 669-6974

Appendix F.3

B.C. Salmon Farmers Association
List of Members (as of June 1992)

Anchor Seafarms Ltd.
PO Box 898
Campbell River, B.C.
V9W 6Y4

Blue Tornado Enterprise Inc.
#205-55 Victoria Road
Nanaimo, B.C.
V9R 5N9

EWOS Canada
7721-132nd Street
Surrey, B.C.
V3W 4M8

Grove Aquafarm Inc.
3437 Caribou Avenue
Powell River, B.C.
V8A 5K1

Intercan Resources 3 Ltd.
#206-1168 Hamilton Street
Vancouver, B.C.
V6B 2S2

Moore Clark Co. (Canada) Ltd.
1350 East Kent Avenue
Vancouver, B.C.
V5X 2Y2

Pacific Aqua Foods
#650-220 Cambie Street
Vancouver, B.C.
V6B 2M9

Paradise Bay Seafarms Ltd.
Box 162
Heriot Bay, B.C.
V0P 1H0

Saga Seafarms Ltd.
PO Box 18
Halfmoon Bay, B.C.
V0N 1Y0

Saltstream Engineering Ltd.
PO Box 954
Campbell River, B.C.
V9W 6Y4

B.C. Packers
PO Box 5000
Vancouver, B.C.
V6B 4A8

Creative Salmon Company Ltd.
4179 River Road
Delta, B.C.
V4K 1R9

General Sea Harvest Corporation
7721-132nd Street
Surrey, B.C.
V3W 4M8

Hardy Sea Farms
Box 12074-1440,555 W. Hastings
Vancouver, B.C.
V6B 4N5

Liard Aquaculture inc.
3837 Mittlenatch Drive
Campbell River, B.C.
V9W 5T7

Nor Am Aquaculture Inc.
1459 Baikie Road, Box 837
Campbell River, B.C.
V9B 6Y4

Pacific National
1425-1075 W. Georgia Street
Vancouver, B.C.
V6E 3L9

Prime Pacific Seafarms Ltd.
PO Box 98
Sooke, B.C.
V0S 1N0

Salt Spring Aquafarms Ltd.
RR#1, C-24 Bulman Road
Fulford Harbour, B.C.
V0S 1C0

Scanmar Seafoods Ltd.
Box 12074, 1550-555 W. Hastings
Vancouver, B.C.
V6B 4N5

Seafarm Canada Inc
1405 Spruce Street
Campbell River, B.C.
V9W 3L6

Strathnaver Pacific Seafarms
PO Box 606
Nanaimo, B.C.
V9R 5L9

Value Resource Ltd.
#436-1755 Robson Street
Vancouver, B.C.
V6G 3B7

Wood Bay Salmon Farm Ltd.
Box 18, Buccaneer, RR#1
Halfmoon Bay, B.C.
V0N 1Y0

Sea Spring Salmon Farm Ltd
PO Box 870
Chemainus, B.C.
V0R 1K0

Sunderland Salmon Farms Ltd.
Box 518
Campbell River, B.C.
V9W 5C1

West Cost Fishculture Lois Lake
609-850 W. Hastings Street
Vancouver, B.C.
V6C 1E2

Chapter X
North and South America

CHILE

Chile is the world's third largest producer of farmed salmon and expects to become the second largest producer within a few years. Harvests have expanded from only 500 metric tons in 1985 to slightly over 34,000 tons in 1991, and production is projected to reach 45,000 tons by 1993. Salmon culture is one of Chile's most important industries, valued at $130 million in 1991 and projected to reach $250 million in 1992.. The country has excellent conditions for salmon culture and growers enjoy lower production costs than many other countries. Chilean salmon producers raise coho and Atlantic salmon and lesser quantities of chinook and cherry salmon. Virtually all of Chile's salmon is exported. Japan is their most important market (over 50 percent), followed by the United States (over 40 percent). Chile replaced Norway as the second major supplier (after Canada) of fresh salmon to the giant U.S. market in 1991-92. Chilean producers are confident that they will be able to continue expanding their share of world markets in 1993.

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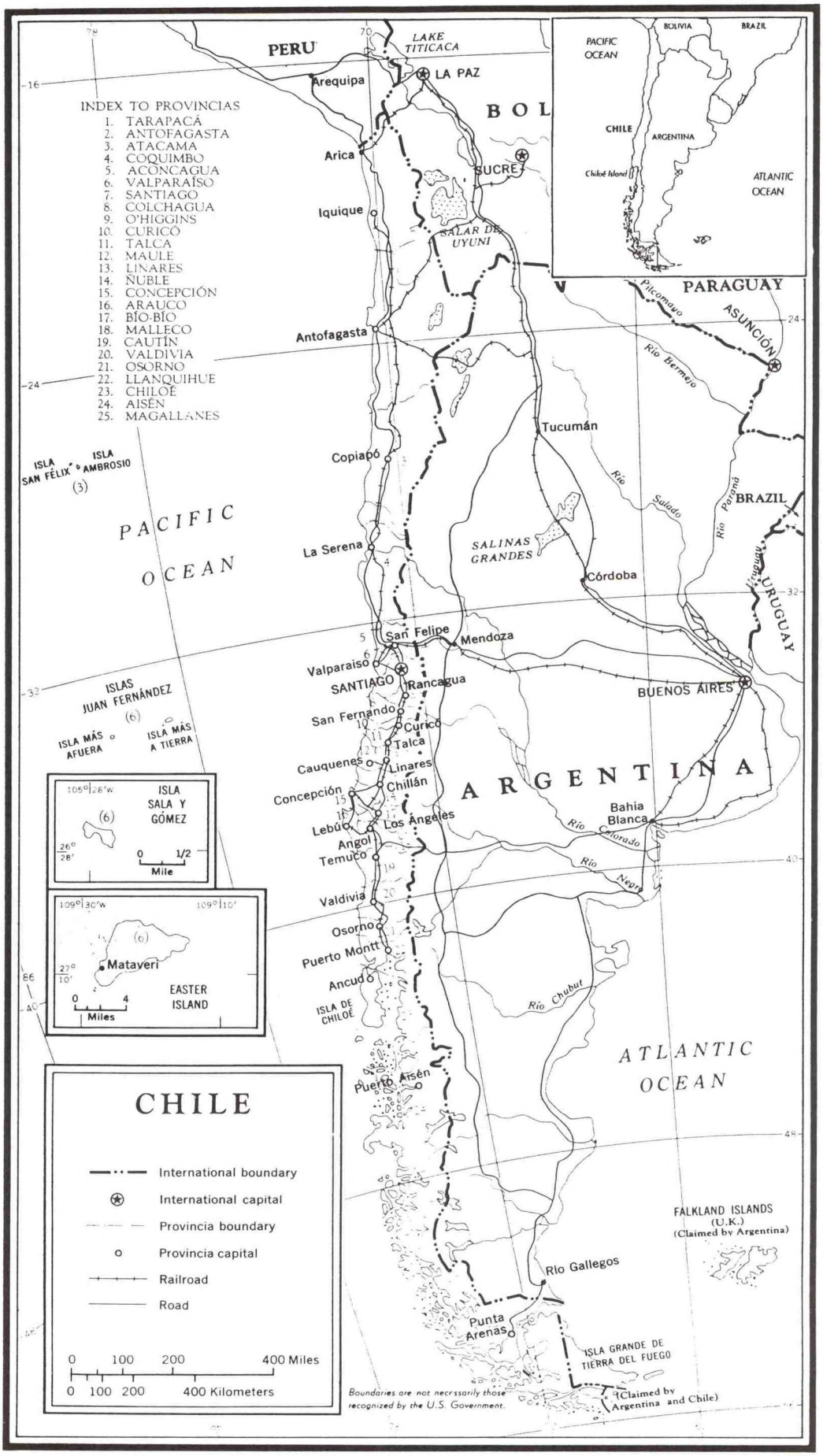

Figure 1.--Map of Chile.

I. GENERAL

A. Overview

1. Historical

Salmon is not native to the southern hemisphere, but Chile's climate and environmental conditions are ideal for a transplanted population. Chile has been trying to introduce salmonid species since 1875. The first successful transplant was reported in 1905, when live sea trout eggs (*Salmo trutta*, also called brown trout in the United States) from Hamburg, Germany were released.[1] This transplant and subsequent egg imports succeeded in establishing a small population of sea trout. The population, however, failed to flourish and was not seen after 1937. The efforts of other individuals to introduce salmon into Chilean waters were unsuccessful.[2] Chile's Fish and Game Division and the University of Washington in Seattle introduced chinook and coho salmon into Chile in 1968.[3] The Chilean Servicio Nacional de Pesca (SERNAP) agreed with the Japanese Agency for International Development (JICA) to once again introduce salmon in 1969. The SERNAP/JICA program was the most sophisticated and ambitious effort to introduce salmon ever attempted. More than 40 million eggs were eventually imported, but again the effort failed.[4] The research findings and training, however, played an important role in the long-term development of a salmon farming industry in Chile.[5] The first commercial salmon ranching effort was made by Domsea Farms in 1976. The first commercial effort to raise salmon in pens came in 1979 when Pesquera Mares Australes Ltda. imported 100,000 coho eggs for raising along with Empresa Pesquera Nichiro Chile, S.A., which also imported coho eggs. The first harvest was made in 1981.[6]

2. Biology

No salmonid species exist in the southern hemisphere; all of the salmon species in Chile have been introduced. Chilean salmon researchers have experimented at various times with all seven salmon species and many different strains.[7] Most Chilean farmers currently culture Pacific coho (*Oncorhynchus kisutch*, called salmón plateado). Chilean farmers experienced early success with cohos; farmers found that cohos were more adaptable to cage culture than other Pacific species.[8] The first harvest was in 1981 and cohos remained the only salmon harvested commercially until 1987. The second species cultured is the Atlantic salmon (*Salmo salar*, called salmón del Atlántico). Atlantic salmon can be grown in larger sizes than coho and harvests of this species are projected to exceed the harvest of Pacific species in 1992. Chinook salmon (*O. tschawytscha*, called salmón rey) is starting to be grown in larger quantities. Very small amounts of pink (*O. gorbuscha*, called salmón perro) and cherry salmon (*O. masou*, called salmón cereza) are also produced.

3. Economic factors

Puerto Montt in south-central Chile is the geographic center of Chile's salmon farming industry (see map). This area is largely agricultural, with a population density comparable to that in North Dakota.[9] Salmon culture is a high-value sector of Chilean aquaculture which has shown remarkable growth. Between 1981 and 1991 production soared from just 1 t to 34,000 t, increasing at a rate of over 100 percent per year. Salmon culture has drawn huge investments in Chile, including over $200 million for production infrastructure and value adding facilities. In conjunction with these developments, investors have also built many modern salmon farms along Chile's southern coast. Salmon culture offers the largely agricultural and fishery based workers of the Chiloé Island and Aysén area the opportunity to expand their economic base. Salmon farming has been a strong magnet not only for federal funds, but for private investment as well, and has served as a strong force for regional development. Salmon farming has also drawn significant foreign direct investment to Chile, attracting companies from Japan, Norway, the United Kingdom, the Netherlands, Canada, and the United States.

4. Natural advantages

Chilean salmon farmers enjoy a significant comparative advantage over farmers in other major producing countries due to Chile's **ideal environment** for salmon culture, and low priced **land**, **feed**, and **labor**. [10]

a. Favorable environment

Southern Chile has an almost ideal environment for salmon culture.[11] The 1,700 kilometer (km) stretch from Puerto Montt south to Punta Arenas, the area most suitable for salmon culture, lies close to the Antarctic Convergence and the world's richest krill fishing grounds.[12] This area has many fast flowing

rivers, and the many islands, inlets, and bays offer a vast number of well-protected sites for potential fish farms. The topography and climate of southern Chile is similar to the salmon habitat of the United States and Canadian Pacific Northwest. The sparse population and lack of industrial development, however, have left southern Chilean waters almost free of pollution. Growers report excellent oceanographic conditions. The Chilean coast has relatively stable water temperatures of 10-15° Celsius, and the water remains ice-free throughout the year. Chile also experiences more sunlight than in the Northern Hemisphere, which leads to increased salmon feeding (and faster growth). The impact of these conditions on Chilean production has been significant. Farmers (many from the UK or Norway) report excellent yields, with growth rates exceeding some of the best Scottish and Norwegian operations.[13]

b. Inexpensive land

Large amounts of land along the southern coast are unoccupied and can be purchased or leased at little cost. Chilean farmers in 1988 could enter the industry with initial investments of as little as $400,000 for a farm capable of producing about 100 metric tons (t) of salmon annually.[14] A hectare of land could be purchased for about $100 in 1989.[15] Farmers in Canada, Scotland, and Norway report significantly higher production and start-up costs.

c. Ample feed

Access to sources of inexpensive feed is a major element in successful salmon farming. Feed is the largest cost in the salmon production process and a critical element affecting growth rates and the quality of the harvested salmon. Most of the feed used by the Chilean "salmoneros" (salmon farmers) is produced domestically.[16] The existence of large stocks of low-value fish (*Clupea sp.* or *Trachurus sp.*) which can be used for feed is one of the key advantages available to Chilean farmers, who have access to major feed components at extremely competitive prices.[17] Abundant stocks and low wage rates make fresh fish much less expensive than in most other salmon producing countries. Fresh fish could, for example, be bought for under $100 per ton and often for as little as $30 in 1989.[18] Fishmeal needed to produce dry feed is also relatively inexpensive in Chile, as the country is one of the world's most important producers of fishmeal, a major component of salmon feed rations.[19]

d. Low wages

Chile reportedly has the lowest wages of any country currently culturing salmon. Subsistence farming and fishing are common in the rural areas and thus labor costs are comparatively low, especially when compared with Norwegian, UK or US wages. In 1987, for example, the annual yearly wage was $90.00.[20] Two years later, in 1989, it was reported that $150 a month is considered a "good" salary.[21]

B. Government policies

The Government of Chile played a limited role in the industry's early development. The Chilean Undersecretary of Fisheries, however, chose in 1987 to adopt a purely regulatory role. The Government regulates permits for salmon site development, approves imports of eggs, and oversees the salmon inspection program. Chile's Government does not interfere with exporter earnings: there are no export taxes and the currency is fully convertible.

One of the reasons that many investors have been attracted to Chile is the absence of governmental red tape that hinders salmon farmers in other parts of the world. This *laissez-faire* attitude includes no restrictions on 100-percent foreign ownership of salmon farms.[22]

II. PROBLEMS

A. Disease

Chilean growers must contend with a number of diseases, most within normal parameters for farmed salmonid populations. A 1989 disease outbreak among Chilean farmed chinook salmon, however, has caused up to 90 percent losses among each successive year's Pacific salmon crop. Experts suggest that at least 1.5 million Pacific salmon have died since the outbreak of the disease. Scientists from all over the world researched this new disease, and have found that it is caused by a previously unknown strain of the *Rickettsia* bacterium. Now dubbed "salmon ricket poisoning," the disease can infect Atlantic as well as Pacific salmon and also occurs in rainbow trout. The bacterium poses a threat to all salmonid species, and there is no known treatment.[23]

Rickettsia bacteria are not a frequent cause of fish disease, but they are well known dangers for humans. The best known *Rickettsia* infection is Typhus, which is passed by the human louse. Apparently, the disease plaguing Chilean salmon entered the population by a similar vector: some parasite common to Chilean coasts passed the bacterium to the transplanted salmon. Antibiotic treatment is not effective against this bacteria. *Rickettsia* bacteria, however, normally provoke large antibody reactions in infected hosts. Salmon farmers hope that those antibodies will provide fish which survive the infection with immunity to reinfection. If the immunity can be passed to offspring, the epidemic will run its course and leave Chilean salmon production intact. If the fish do not develop immunity, mortality rates as high as those experienced in the farmed chinook populations may severely impact Chilean salmon farming.[24]

B. Algae blooms

In September 1988, Chilean salmon growers were confronted by a sudden phytoplankton bloom. This "brown tide" was unknown to local fishermen as Chilean waters are not normally affected by algae blooms. The right combination of environmental conditions -- high sea water temperatures, mild winds, and a high atmospheric insolation -- created conditions for the algae to bloom. The equivalent of 2,000 t of salmon were suffocated by the algae. Algae blooms are not anticipated, but could appear again given the right combination of environmental conditions.[25]

C. Infrastructure

The absence of roads or transportation systems in remote areas makes transportation a costly undertaking. Inadequate cold storage facilities, processing plants, etc. hinder development; many facilities must be completely self-sufficient. The lack of qualified and experienced personnel is another problem; many managers, technicians, and scientific support staff are from other countries and it will take time for Chile to develop a cadre of well-trained people.[26] Despite these difficulties, Chile's explosive growth in salmon farming suggests that many of these problems have been overcome or reduced to acceptable limits.

D. Distance to market

Chile is far removed from distant markets, making airfreight and seafreight expensive. It was estimated that shipping 10,000 t of fresh salmon requires 200 charter flights![27] Air freight is at a premium between December and March of each year when most of Chile's coho is harvested. This is also when large quantities of fruit, berries, and flowers are exported. Transportation of these items places a strain on the Chilean transportation system.[28]

III. HARVESTS

A. Eggs

Chilean growers obtain eggs from local hatcheries and foreign countries. Domestic eggs are usually produced by the same companies which culture salmon.[29] The United States is a source for Pacific salmon eggs while Norway and Scotland supply Atlantic salmon eggs. Chile's total capacity to produce eggs domestically was 50 million ova capable of yielding 40,000 t of adult fish per year in 1988.[30] In 1991 Chile was still producing only 25 percent of its total egg requirements and importing the rest (25 million coho, 25 million Atlantic, and 1 million other salmon species).[31] The Universities of Chile and California have established a genetic improvement program based at the Instítuto de Fomentos Pesqueros at the Coyhaique facility. The program is designed to improve the quality of coho salmon as a farmed fish. The plan is to reduce mortality and increase resistance to diseases through selective breeding. Better growth and food conversion are other goals of the project.[32]

B. Smolts

Chilean smolt production increased to 13.2 million in 1991. Observers estimate that production will increase to 16.8 million in 1993. Lever Chile, which is heavily involved in raising Atlantic salmon, imported salmon eggs from Scotland and built a hatchery near Lake Puyehue in southern Chile. The company reported rapid growth rates during the alevin stage, apparently because of warm waters. Smolts are raised by the company at a site southeast of Puerto Montt. Chisal S.A., operates a "state-of-the-art" Atlantic salmon hatchery with a production capacity of over 1 million smolts at Rio Negro.[33] Salmones Huillinco S.A. is another company that is able to provide Atlantic salmon smolts to Chilean salmon producers.[34] Other companies have begun

raising smolts. Domestic production of both eggs and smolts will lessen dependency on foreign suppliers and reduce the possible introduction of disease into Chile.[35]

C. Salmon

1. On-growing

The first Chilean net pen operations were initiated by a Japanese company, Nichiro Chile, in 1979. Two other groups initiated projects in 1979 and 1980. All of the early projects focused on Pacific salmon, mostly coho. As these and other groups demonstrated the feasibility of net pen culture, many small Chilean investors entered the industry. The first major harvest was not reported until 1985, when around 500 t were harvested. This prompted many business groups, including foreign companies, to invest in the industry. By the end of 1985, 31 groups were authorized to culture salmon. Harvests grew rapidly during the next five years (table 1). Most of Chile's early production consisted of coho salmon. The cohos were easy to raise during their freshwater phase and were quick to mature.[36] However, they returned to spawn only during 3 months of the year: December to March (opposite the cycle in the northern hemisphere). Harvesting fresh salmon in December-March provided Chile with the unique opportunity to market fresh Pacific salmon when most northern fishermen were tied up in port. This became an important medium-term market development strategy for Chile.[37] The drawback was that the processors were flooded with salmon. Also, if farmers harvest too soon, the fish are too small; if harvested too late, the flesh losses its distinctive color and begins to degenerate.[38] Much of the growth of the coho, chinook, and cherry salmon farming industry was stimulated by Japanese investors.

Norwegian investors were also interested in Chile. In 1985, the Norwegian company NorAqua established a subsidiary called Chisal and built the country's largest Atlantic salmon hatchery in Rio Negro.[39] Unilever, a $35-billion British conglomerate, quickly followed; the company was a major salmon farmer in Scotland and knew the marketing opportunities for Atlantic salmon. Unilever's plans included construction of a feed plant, hatcheries, processing lines, and smoking facilities; a total investment of nearly $10 million. The Unilever operation at Puerto Montt is now one of the largest operations in Chile and the island of Chiloé is the salmon capital of Chile.[40]

Between 1980 and 1990, the number of salmon farms in Chile doubled. There were approximately 480 farms sites licensed in 1989, but only 120 sites were in operation.[41] Many farms were built on the island of Chiloe in the early 1980s, but farms have since been built in other parts of the country. The Aysén fjord, the Puyihuapi channel and Guatecas island may become important salmon farming areas in the future.[42]

Much of Chile's harvest was sold as fresh, head-on salmon to U.S. buyers. In 1988, however, Japanese companies began buying increasing quantities of frozen salmon, particularly cohos.[43] Chilean exports to Japan went from 28 t in 1987 to over 1,000 t in 1988, reached 10,600 t in 1990 and 14,600 t in 1991 (see chapter V. Exports). Exports to the United States also grew rapidly, reaching nearly 11,500 t in 1991. This record was reached during a time when most world markets were oversupplied with salmon.

Chilean salmon farmers harvested over 34,000 t of salmon during 1991, a 40 percent increase over the 23,000 t harvested in 1990. The 1991 harvest included 17,954 t of coho, 1,059 t of chinook, and 105 t of cherry salmon. The harvest also included 14,957 t of Atlantic salmon (see Appendix).[44] Many observers expect Chilean harvests to continue increasing, and predict a harvest of 45,000 t by 1993. Other growers are less optimistic and expect harvests to level off. These growers believe that the fall in world salmon prices and lower profit margins will discourage future investment in the industry.[45]

2. Ranching

Chile offers ideal conditions for salmon ranching. The area **south** of Puerto Montt is influenced by ocean currents which carry smolts southward past Cape Horn into the Scotia Sea, a cold, plankton-rich area, where krill is found in abundance.[46] To the **north** of Puerto Montt, however, the Humbolt Current flows northward, pushing smolts into warmer waters where they are unlikely to survive.[47] The only successful salmon ranches in Chile were those located south of Puerto Montt. This may also explain why all efforts to release fish north of Puerto Montt have failed. There is a 1,700 kilometer (km) coastline between Puerto Montt and Punta Arenas where salmon smolts could be ranched, with a projected return of 68,000 t of salmon annually.[48] Efforts to seed these waters involved many efforts over the years. The SERNAP/JICA program, for example,

released millions of eggs, including 5 million "Atkins" type chum salmon.[49]

The Domsea Farms (owned by Campbell Soup and formerly owned by Union Carbide) started seeding Chilean waters in the 1970s.[50] The company was able to report significant returns of coho and chinook salmon released into Chilean waters; this was the first successful salmon ranching venture in Chile. The project began in 1976 with the establishment of a rearing facility at Lake Popetan on Chiloé. Domsea released close to 100,000 smolts in 1977-78. The company continued to release salmon smolts in 1978 and the first returns were reported in 1979. The Salmones Antartica Ltd., however, attempted to commercially ranch coho and chinook salmon in the early 1980s. The company established two facilities near Castro on Chiloé and a third facility at Magallanes near Puerto Natales. The company released 1 to 1.5 million smolts annually, mostly chinook. Returns were averaging about 1 percent and most of the fish were used as broodstock in the hope that Chilean-bred fish would become established.[51] Salmones Antartica Ltd. reported its first returns chinook in 1985.[52] The company was reportedly still successfully operating a ranching operation in 1988, although with only limited production.[53] The first returns from the Japanese-Chilean efforts begun in 1974, were reported in 1988, when Aysén chum salmon from eggs furnished by hatcheries in Hokkaido began to appear. This was part of the SERNAP/JICA effort to introduce salmon into Chile's waters.[54] In 1990, the Salmotec SA (formerly Salmones Antartica SA), reported "spectacular" returns from their salmon ranching operations. The company reported that chinooks weighing 10 to 24 kilograms (kg) and coho weighing 3 to 6 kg. were returning in good quantities (5 percent of smolts released versus as few as 0.5 percent in previous years).[55] The company stripped 5 million chinook and 4 million coho eggs from the returning fish which it sold to salmon farms in Chile. It also planned to raise some of the eggs into smolts for release near Natales. In 1991, there were 7 ocean ranches operating in Chile.[56] The largest chinook salmon ever caught in Chile was taken when it returned to the Salmotec S.A.'s Rio Salmon Ranch near Puerto Natales in the Magallenes. The fish weighed 31.5 kg. and is thought to have come from the first chinook incubated at the Rio Prat facility in 1983; at that time 60,000 chinook eggs from Washington State were imported and 30,000 smolts from this shipment were released in 1983.[57]

IV. ASSOCIATIONS AND COMPANIES

A. Associations

Chilean salmon producers organized the *Association of Chilean Salmon Farmers*[58] in August 1986. The Association, begun by 17 Chilean salmon companies, currently includes 42 members, seeks to maintain quality standards and market Chilean salmon abroad.[59] The Association established a certification program in conjunction with *Fundacion Chile*[60] in 1987 to guarantee the quality of Chilean farmed salmon. The Foundation claims to certify 85-90 percent of the country's salmon exports. The program appears to be successful, as foreign buyers consistently rate Chilean salmon as excellent.[61] The Association aggressively markets Chilean salmon in the United States and Japan, and has utilized print advertising, booths at seafood shows, and tours of Chilean salmon production facilities for U.S. journalists to market the product. The association's members produced more than 10,000 t worth $60 million in 1988 and projected harvests of 14,000 t worth $80 million in 1989-90.

Association of
Chilean Salmon
Farmers

B. Companies

Chile's salmon industry is dominated by a few large companies, primarily foreign owned. Most of these companies operate numerous salmon farms. The most important companies include: **Marine Harvest** (the Unilever subsidiary which owns most of the Scottish salmon industry). A Marine Harvest team visited Chile in 1986 and decided to grow Atlantic salmon in Chile as a result of the trip. **Sociedad Lago Ilanquihue Ltd.**, and **Pesquera Unimarc** (which is wholly owned by Chilean investor Francisco Javier Errazuriz) are other important fish farms that played a pioneering role in Chile's development. Chile's pioneer salmon company, **Salmones Antarctica**, one the largest salmon farm operations in Chile, was later purchased by Nippon Suisan.[62] **Lever Chile** (a subsidiary a Unilever) began operating an Atlantic salmon farm in 1987 at a $10 million facility. The company hoped to produce 2,500 t of salmon by 1990 and eventually increase their harvest to 10,000 tons! The **Swan Foundation**, financed by the Norwegian Government, also initiated an Atlantic salmon project in Chile in 1986. Other companies associated with raising Atlantic salmon include **Chisal, Pesqueras Mares Australes**, and **Soc. Agricola Aguas Claras.**[63] Some of the leading producers in Chile include **Aquasur, Mainstream, Unimarc,** and **Salmones Aucar.**

Growth of the industry has been rapid. There was only one company operating in 1980. By 1985, a total of 58 companies were licensed.[64] By 1988, there were 91 salmon farms in operation, employing more than 1,000 people. Most of the farms (70 percent) were located in southern Chile and 24 of these farms had their own smolt production facilities.[65] Salmon farming helped to drive unemployment to the lowest levels in the Chiloé area.[66] In 1991, 126 companies operated 471 Atlantic salmon farms; 41 companies operated 523 farms culturing Pacific salmon. There are no records of bankrupt farms, but 130 farms (both Pacific and Atlantic) were inactive during 1991.[67]

V. EXPORTS

Virtually all of Chile's salmon harvest is exported.[68] Chile exported over 27 thousand t of salmon in 1991, with a value of over $135 million.[69] Most Chilean salmon is exported to Japan, followed by the United States and the European Community (table 2).

Table 2.--Chile. Salmon exports by country, 1981-91.

Year	Country			Total
	U.S.	Japan	EC	
		Metric Tons		
1981	-	5	96	101
1982	10	51	28	89
1983	-	33	-	33
1984	32	-	-	32
1985	145	-	-	145
1986	683	45	-	728
1987	860	28	-	888
1988	1,175	1,064	-	2,239
1989	2,085	4,011	195	6,291
1990	8,919	10,573	407	19,899
1991	11,458	14,635	386*	26,479

NA - Not available
* - Only includes Germany and Spain
Sources: Japan Tariff Association (Japanese data), U.S. Census Bureau (U.S. data), EC Nimexe (EC data).
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A. Japan

Japanese imports of Chilean salmon were 14,500 t in 1991, or 53 percent of Chile's total salmon exports. Most of this was frozen coho salmon. Chile only exported small quantities of salmon to Japan between 1981-87, but shipments increased sharply in 1988 and have continued to grow. In 1989, the Chilean Salmon and Trout Growers' Association visited Japan to study the market and meet buyers.[70] The objective of the visit was to find outlets in Japan for 4,000 t of salmon in 1990. Chilean growers consider the Japanese market their most important market for future expansion, and plan to focus their marketing efforts there.[71] The Japanese prefer Chilean salmon because of its intense color and freshness and because of the high quality of the Chilean product.[72] The trip was worthwhile because Chilean exports to Japan have increased significantly in recent years despite the availability of wild, North Pacific salmon.

B. United States

U.S. imports of Chilean salmon were 11,400 t or 42 percent of Chile's total salmon exports in 1991. Chilean shipments to the United States increased nearly 30 percent over the 8,900 t shipped during 1990 and generated $56 million in export sales (appendix section). Most of this was fresh Atlantic salmon, but modest quantities of frozen and smoked

salmon were also shipped to the U.S. market. Chile took advantage of U.S. countervailing duties against Norwegian salmon to become the second largest supplier of farmed salmon to the United States in 1991. The Chileans accomplished this through aggressive, competitive pricing. This may have contributed to a "bargain basement" image for Chilean salmon, but it certainly has not hurt Chilean exports to the United States. Chilean growers now have the option to increase their prices and use the profits to invest in promotional programs designed to appeal to broad segments of the population. The marketing campaign undertaken by Chilean producers has become increasingly sophisticated in recent years. The Chilean pavilion at the Boston Seafood Show in March 1992, for example, was attractively designed and visitors received impressive promotional materials.

C. Other markets

Chilean salmon farmers export a small amount of salmon (mostly Atlantic) to the EC, primarily France, Spain and Germany. The Association of Chilean Salmon Farmers is initiating a European marketing program.[73] There is a good chance that Chilean salmon exports to Europe, primarily destined for the smoking trade, will increase in 1993. This is especially true if shortages occur in the EC market in late 1992. The Chileans are well positioned to supply large quantities of salmon if prices increase. A small but growing amount of salmon is being shipped to Argentina and Brazil.[74] After the U.S. and Japanese markets are supplied, however, Chilean exports to all other countries amount to only 5 percent of Chile's total output. In all, Chile exported salmon to over 20 countries during 1991. Chile has a very small domestic market for its farmed salmon products.

VI. OUTLOOK

Chile has established itself as one of the world's most important producers of cultured salmon. It seems certain that Chile's salmon industry will continue to grow, and harvests could reach 38,000 t and exports could be worth $230 million in 1992. Farmed Atlantic salmon will continue to grow in importance. It is easier to grow in it's saltwater phase (coho are easier to raise in their freshwater phase, but difficult to keep in saltwater pens), and generate better returns. Also, Atlantic salmon can be harvested throughout the year, whereas coho can only be harvested during 3 months of each year.[75] Fresh coho for the Japanese market could become an important new market for Chile, complimenting an existing market for frozen product. There is also a potential market for exporting salmon roe to Japan.

The most important challenge facing Chilean growers is to increase their market share in Europe, Japan, and the United States. If shortages develop towards the end of 1992 or during 1993, the Chileans will be able to move aggressively to create new, profitable markets. The outlook for Chile, thus, appears quite favorable for the next few years.

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Appendix G

Chile

Table 1.--Chile. Farmed salmon harvests by species, 1980-91.

Year	Pacific salmon				Atlantic salmon	Total
	Chinook	Coho	Cherry	Total		
	Metric Tons					
1980	-	-	-	0	-	0
1981	-	1	-	1	-	1
1982	-	184	-	184	-	184
1983	-	94	-	94	-	94
1984	-	109	-	109	-	109
1985	-	500	-	500	-	500
1986	-	1,144	-	1,144	-	1,144
1987	-	1,780	-	1,780	41	1,821
1988	3	4,040	-	4,043	165	4,208
1989	11	6,933	-	6,944	1,860	8,804
1990	389	13,413	29	13,831	9,498	23,329
1991	1,059	17,954	105	19,118	14,957	34,075

Source: Servicio Nacional de Pesca, *Anuario Estadistico de Pesca*, various years.

Table 2.-- United States. Imports of farmed salmon from Chile, 1984-91.

Year	Imports			Total	
	Fresh	Frozen	Smoked	Quantity	Value
	Metric Tons				*US$1,000*
1984	32	0	0	32	144
1985	145	0	0	145	610
1986	679	4	0	683	2,931
1987	839	21	0	860	4,052
1988	1,175	0	0	1,175	6,619
1989	2,068	15	2	2,085	10,798
1990	7,383	1,505	31	8,919	48,005
1991	11,260	196	2	11,458	56,419

Source: U.S. Bureau of the Census.

Table 3. --United States. Imports of fresh salmon from Chile, by quantity and month, 1984-91.

Month	Fresh Imports							
	1984	1985	1986	1987	1988	1989	1990	1991
January	0	2,356	105,307	143,351	445,561	194,272	481,878	1,192,217
February	6,275	3,579	175,567	278,839	397,489	273,265	677,645	922,798
March	19,966	55,195	299,840	280,963	243,015	173,346	834,579	939,175
April	1,890	72,951	26,316	15,466	31,192	37,876	594,299	553,139
May	840	3,168	0	11,052	0	42,917	423,905	594,437
June	0	0	4,726	0	4,055	47,908	552,323	742,778
July	0	998	1,315	0	5,575	75,008	333,180	543,477
August	0	0	5,905	2,195	0	126,876	295,987	900,496
September	0	0	0	0	0	172,359	448,031	1,109,848
October	0	0	0	0	0	295,468	762,014	1,023,266
November	0	0	0	21,693	2,679	270,785	657,945	1,207,817
December	3,360	6,335	60,419	85,224	45,635	358,019	1,320,956	1,530,727
TOTAL	32,331	144,582	679,395	838,783	1,175,201	2,068,099	7,382,742	11,260,175

Source: U.S. Bureau of Census. Note: Import statistics show that the U.S. imported 10,763 kilograms of fresh Chilean salmon worth $44,464 in April 1982.

Table 4. --United States. Imports of fresh salmon from Chile, by value and month, 1984-91.

Month	Fresh Imports							
	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00							
January	0	10,232	435,971	645,898	2,457,196	1,035,674	2,446,413	5,783,112
February	24,988	13,596	750,080	1,260,647	2,128,525	1,475,867	3,414,121	4,690,158
March	90,252	234,599	1,288,983	1,290,115	1,462,083	924,668	4,194,612	4,481,802
April	9,060	297,344	105,328	68,846	231,120	197,612	2,902,086	2,873,136
May	5,040	12,672	0	85,572	0	207,481	2,272,032	2,959,775
June	0	0	26,555	0	30,741	236,434	3,008,716	3,912,087
July	0	8,800	6,723	0	42,798	378,223	1,906,575	2,789,313
August	0	0	17,370	16,000	0	666,959	1,859,021	4,440,060
September	0	0	0	0	0	882,235	2,794,415	5,302,483
October	0	0	0	0	0	1,477,365	4,514,235	5,080,418
November	0	0	0	154,069	11,473	1,401,630	4,087,350	5,918,517
December	14,266	32,447	280,119	489,933	254,900	1,817,494	6,678,182	7,123,413
TOTAL	143,606	609,690	2,911,129	4,011,080	6,618,836	10,701,642	40,077,758	55,354,274

Source: U.S. Bureau of the Census. Note: Import statistics show that the U.S. imported 10,763 kilograms of fresh Chilean salmon worth $44,464 in April 1982.

Table 5. --United States. Imports of frozen salmon from Chile, by quantity and month, 1986-91.

Month	Frozen Imports					
	1986	1987	1988	1989	1990	1991
	Kilograms					
January	0	0	0	5,040	47,511	29,200
February	4,191	0	0	5,998	66,576	10,174
March	0	0	0	1,194	108,041	8,269
April	0	0	0	1,133	63,880	14,113
May	0	0	0	0	83,287	3,196
June	0	5,000	0	0	34,412	4,313
July	0	16,398	0	0	105,249	15,584
August	0	0	0	0	309,590	11,509
September	0	0	0	1,152	272,801	22,306
October	0	0	0	0	166,094	20,871
November	0	0	0	0	223,241	40,211
December	0	0	0	0	24,602	16,706
TOTAL	4,191	21,398	0	14,517	1,505,284	196,452

Source: U.S. Census Bureau.

Table 6. --United States. Imports of frozen salmon from Chile, by value and month, 1986-91.

Month	Frozen Imports					
	1986	1987	1988	1989	1990	1991
	US$1.00					
January	0	0	0	30,616	151,950	143,483
February	19,409	0	0	25,088	247,590	63,126
March	0	0	0	4,889	705,366	45,373
April	0	0	0	5,130	371,621	63,756
May	0	0	0	0	485,608	17,018
June	0	7,752	0	0	161,351	26,808
July	0	32,797	0	0	523,989	77,953
August	0	0	0	0	1,575,916	59,081
September	0	0	0	7,195	1,353,980	106,496
October	0	0	0	0	846,203	110,229
November	0	0	0	0	1,076,182	239,764
December	0	0	0	0	106,707	93,698
TOTAL	19,409	40,549	0	72,918	7,606,463	1,046,785

Source: U.S. Bureau of the Census.

Table 7. --United States. Imports of smoked salmon from Chile, by quantity and month, 1989-91.

Month			
	1989	1990	1991
	Kilograms		
January	0	0	1,149
February	0	0	0
March	0	0	0
April	0	0	0
May	0	227	0
June	454	885	486
July	0	2,296	0
August	1,346	7,494	0
September	182	11,602	0
October	0	8,669	0
November	0	0	0
December	0	0	0
TOTAL	1,982	31,173	1,635

Source: U.S. Bureau of the Census.

Table 8. --United States. Imports of and smoked salmon from Chile, by value and month, 1989-91.

Month			
	1989	1990	1991
	US$1.00		
January	0	0	15,491
February	0	0	0
March	0	0	0
April	0	0	0
May	0	2,880	0
June	7,542	9,019	2,527
July	0	24,736	0
August	12,054	58,477	0
September	3,800	126,873	0
October	0	98,344	0
November	0	0	0
December	0	0	0
TOTAL	23,396	320,329	18,018

Source: U.S. Bureau of the Census.

Chapter X
North and South America

UNITED STATES[1]

U.S. harvests of farmed salmon have gone from 300 metric tons in 1980 to slightly over 7,100 tons worth $30 million in 1991. Farmed salmon are raised on both the Atlantic and Pacific coasts. Maine is the leading U.S. producer of Atlantic salmon but recently has begun raising steelhead.[2] California and Washington raise Atlantic and Pacific salmon. U.S. farmed salmon producers have experienced marketing problems in recent years. In part, their difficulties stem from the record catch of wild Pacific salmon between 1989 and 1991. U.S. salmon farmers also faced growing competition from Norwegian, Chilean, Canadian and other growers in the U.S. market between 1989 and 1991. In the case of fresh, farmed Norwegian salmon, a group of Maine salmon farmers complained to the U.S. Government about alleged dumping. Following an investigation, the U.S. Government imposed subsidy and anti-dumping duties on imports from Norway in 1990-91. This resulted in a significant reduction in Norway's exports of fresh salmon to the United States and afforded the Maine industry some relief; harvests of Atlantic salmon in Maine went from 1,500 tons worth $10 million in 1989 to 4,700 tons worth nearly $30 million in 1991. However, exports of fresh salmon from Chile, Canada, and other countries have continued to grow in recent years which has resulted in competitive pricing for salmon products in the U.S. market. U.S. imports of all fresh or frozen salmon were 48,600 tons worth $243 million in 1991.

CONTENTS

I. GENERAL

A. Overview

The United States ranks as one of the world's largest producers of Pacific salmon. This production is, however, based on the landings of wild Pacific salmon which totaled 355,295 metric tons (t) in 1991. The United States cultures modest quantities of farm-raised chinook (*Oncorhynchus tschawytscha*), coho (*O. kisutch*), and Atlantic salmon (*Salmo salar*), as well as steelhead (*O. mykiss)*. Efforts to raise salmonids in the United States began in 1804, with the eastern char (*Salvelinus fontinalis*). The first hatchery for Pacific salmon was built on the McCloud River in California in 1970.[3]

B. Government policies

United States permit regulations require that firms seeking to establish salmon farms must receive approval from federal, state, and local authorities. In doing so, applicants must prove that the site they have chosen is suitable, and often site applications face resistance and legal opposition from environmental groups and nearby residents.[4] Producers reported that the regulations and requirements of the industry are more constrictive in Washington than in Maine, but producers in both states claim that the difficulty, cost, and time span involved in siting salmon aquaculture prohibit industry expansion.[5]

II. MARKETING PROBLEMS

The U.S. salmon farming industry began to feel the impact of increasing salmon imports and lower prices in the late 1980s. U.S. imports of fresh salmon (all species) doubled from 22,600t worth $155 million in 1988 to 45,000t worth $229 million in 1989.[6] U.S. imports of fresh, Atlantic salmon went from 17,505t worth $108 million in 1989 to 22,000 t worth $138 million in 1990 and 22,700 t worth $132 million in 1991.[7] U.S. imports of all fresh or frozen salmon amounted to 48,600 t worth $243 million in 1991.[8] Salmon was ranked as the fifth most popular seafood, in order of consumption, in 1991.[9] Thus, there is ample room for selling farmed salmon in the U.S. market.

On February 28, 1990, the "Coalition for Fair Atlantic Salmon Trade" (FAST), a group of 21 Maine Atlantic salmon farmers, filed a petition with the U.S. International Trade Commission (ITC) and the U.S. Department of Commerce, alleging that the Government of Norway was subsidizing its salmon aquaculture industry and that farmed Atlantic salmon from Norway was being sold at less than fair value.[10] Many Maine salmon farmers reported that low Norwegian prices were adversely affecting their own sales and profits and that it was increasingly difficult for them to obtain bank loans.[11]

The ITC determined on April 16, 1990, that there was a reasonable indication that U.S. salmon farmers were injured by imports of low-priced fresh Norwegian salmon. On April 25, 1990, these determinations were published in the *Federal Register* (55 F.R. 17507). The International Trade Administration (ITA) of the Department of Commerce issued a "Preliminary Affirmative Countervailing Duty Determination" against fresh and chilled Atlantic salmon from Norway on June 21, 1990. The investigation found that Norwegian salmon producers and exporters had benefitted from subsidy programs amounting to 2.43 percent *ad valorem* for all salmon exports.

The U.S. Department of Commerce, on September 26, 1990, imposed a 2.96 percent anti-dumping duty on imported fresh and chilled farmed Atlantic salmon from Norway. The ITC made its final ruling on February 25, 1991, when it determined that Norwegian farmed Atlantic salmon was sold at less than fair value in the United States. The Department of Commerce then announced company-specific, weighted-average dumping margins, ranging from a low of 15.65 percent to a high of 31.81 percent.[12] United States importers of fresh, farmed Atlantic salmon were required to post a cash deposit, bond, or other security in the amount of the dumping margin in order for these goods to enter the United States. This was in addition to the 2.27 percent *ad valorem* payment based on the net subsidy determined to have been paid by the Government of Norway to salmon farmers.

Norwegian salmon sales (all forms) to the U.S. slumped from 9,450 t (worth $64 million) during 1990 to only 1,320 t (worth $12 million) in 1991[13]. United States imports of fresh salmon (all species) from all countries increased to 48,530 t worth $253 million in 1990 and remained close to 48,530 t worth $243 million in 1991.[14] Imports of fresh Atlantic

salmon totaled 16,305 t, valued at $104 million, in 1990 and 9,147 t, valued at $57 million, in 1991; this reflects the drop in Norwegian exports to the United States in 1991.[15]

III. HARVESTS

A. Smolts

There were 8 farms located in Washington that were raising salmon fry in 1975 and 2 of these farms were experimenting with salmon ranching.[16] There were 3 similar facilities under construction or operating in Maine in 1975.[17] The number of companies reporting freshwater production capacity rose from 6 during 1987 to 11 by 1990. During the 1987-89 period, smolt production increased more than 10 times, increasing from 36,500 smolts during 1987 to 388,500 smolts during 1989. Production leveled off somewhat during 1990, amounting to 434,200 smolts (an increase of almost 90 percent over 1989 smolt harvests).[18]

Farmers in both Maine and Washington reported shortages of quality Atlantic salmon smolts before the 1989 season. Partially because of this smolt shortage, 3 U.S. salmon firms raised a "landlocked" species of salmon which did not reach ideal marketable weight.

B. Salmon

1. Pacific coast

The first attempts to raise salmon in the United States took place when the Bureau of Commercial Fisheries (the predecessor of the National Marine Fisheries Service) began experimenting with floating pens in 1967. Commercial salmon farming began in 1970. Harvests of salmon grew slowly and reached 329 t in 1980. During the next decade harvests grew to slightly over 7,100 t in 1991. Salmon farming in the United States started in the Puget Sound area of **Washington** in the early 1970s. **California**[19] and Washington have increased their harvests of Atlantic salmon in recent years (table 1). Harvests of cultured Pacific salmon species have not grown as rapidly as harvests of Atlantic salmon. Limited pen-rearing of pan-sized coho salmon have begun in **Idaho**. There have been some experimental efforts to raise salmon in **Hawaii**.[20] Salmon ranching took place in **Oregon**, starting in the 1970s, but no information is available and it is assumed that all salmon farming has ceased, although recent reports indicate that some farming of pan-sized coho salmon has started in Oregon in recent months. The outlook is for production in Washington to reach 5,000 t in 1992.

2. Atlantic coast

Maine salmon farmers have increased their harvests of Atlantic salmon from 23 t in 1984 to slightly over 4,700 t in 1991 worth about $26 million. Maine now accounts for over 50 percent of total U.S. salmon harvests and salmon aquaculture is Maine's second most valuable fishery after lobster. Some believe that the value of the salmon farming industry will exceed the dockside value of lobster within 2 years.[21] There were 3 farms growing Atlantic salmon in Maine in 1987 and this grew to 10 salmon (and steelhead) farm sites in 1989. The number of sites increased to 17 sites in 1990 and reached 19 farm sites in 1991.[22] Employment included 117 individuals directly and indirectly employed in 1987 and 265 persons in 1990.[23] The outlook for Maine's production is for 8,000 t in 1992. Some salmon are being raised in abandoned quarries in **Minnesota**.[24] Reports indicate that this project is not very successful.

IV. OUTLOOK

The outlook for continued expansion of the United States farmed salmon industry is uncertain. The industry faces strong opposition from citizens groups concerned about environmental damage, degradation of scenic beauty, possible impacts of fish farms on the value of adjacent land, etc. Thus, the opportunity to significantly expand is somewhat limited. The industry has a few possible options: (1) move offshore, (2) develop salmon farming in Alaska, (3) improve existing facilities through the application of modern technology, or (4) develop onshore facilities. The development of salmon farming in Alaska appears unlikely. Opposition against salmon farms in Alaska has been loud and effective. The State of Alaska has indicated that it would not allow salmon farming to begin in the state because of fears of environmental contamination of Alaska's valuable wild fisheries, which yielded 330,000 t of salmon valued at $312 million in 1991.[25] The outlook for expansion offshore remains uncertain. Applications to develop a new salmon farming operation well off

the coast of Maine have been raised, and the issue was being examined by officials of the National Marine Fisheries Service, NOAA, U.S. Department of Commerce. No decision had been reached at the time of this writing. In summary, it would appear that the industry's best hopes lie in the application of new technology to existing fish farming facilities. The possibility of on-shore processing remains an illusive, and expensive option, that could be used in the future.

Despite some of the problems facing the industry, the outlook for U.S. harvests is good. The current outlook for U.S. salmon production is for harvests to reach 13,000t in 1992.

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ENDNOTES

1. The Office of International Affairs does not follow trends in the United States.

2. This report does not consider farming of steelhead. That species was recently reclassified as a member of the Pacific salmon genus.

SECTION I (General)

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Chapter XI

Pacific

CHINOOK SALMON

(Oncorhynchus tshawytscha)

Artwork courtesy of the Association of Chilean Salmon Farmers

Chapter XI
Pacific

AUSTRALIA

Australian salmon culture is centered in the southern island-state of Tasmania (figure 1), with a 1991-92 harvest of 3,300 tons[1] (figure 2). This is nearly a 16-fold increase in production since the inception of commercial salmon culture. Australian harvests consist almost entirely of non-native Atlantic salmon (*Salmo salar*), with a substantial percentage exported to Japan. Harvests are expected to increase further during the 1990s, but at a slower rate. Observers feel Australia's maximum potential annual production to be in the range of 5,000 tons. A lack of inshore farm sites and a moratorium on smolt production until 1995 are the major restraining factors.

CONTENTS

I. GENERAL

A. Overview

Salmon is the most valuable sector of the Tasmanian aquaculture sector. The salmon industry has grown rapidly since salmon eggs were first imported in 1984. Infrastructure was initially modelled after Norwegian technology, but has now been adapted to the Tasmanian environment. The industry has developed to the point where it can even export salmon culture equipment to mainland Australia and foreign markets. Most farmers grew both trout and salmon in the early days of the industry, but farmers have moved from trout to salmon because salmon has been easier to culture and has a better feed conversion ratio and higher market prices.[2]

B. Government policies

Aquaculture in Australia is under the responsibility of the States and Territories and not the central Government. The State/Territory fisheries authorities have different reporting requirements for harvesters, and the data collected is rather scarce. State and Territory fishery authorities are slowly developing administrative structures for regulating the aquaculture industry.[3] Harvests center on oysters, but salmon has now become a viable industry in Australia.

Figure 1.--Map of Australia.

II. HARVESTS

Salmon farming in Australia began in earnest after the Tasmanian Government and Norway's Noraqua Group established a joint venture to produce Atlantic salmon in 1985. The Tasmanian Government holds 51 percent of the joint venture's shares, Tassal Limited 26 percent, with the remainder held by other salmon farmers. The joint venture company (known as **Saltas**) operates the country's sole hatchery. The prospects for development of salmon farming in Tasmania are good because of favorable natural conditions and because broodstock are free of the major disease problems inherent in northern hemisphere production.[4]

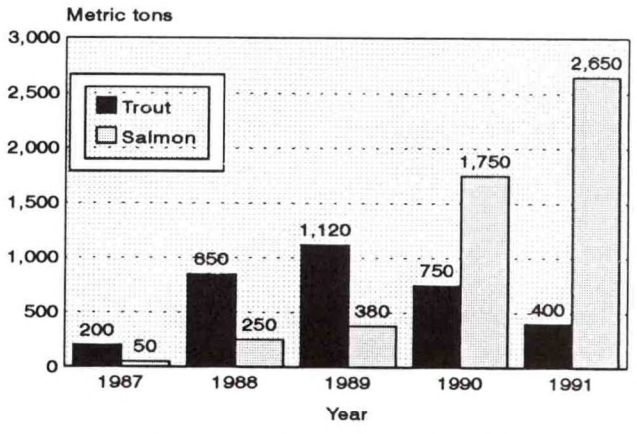
Tasmanian salmon farms covered approximately 500 hectares in 1990.[5] There were 36 farms licensed to raise salmon in Tasmania (and 36 farms licensed to grow rainbow trout) in 1991.[6] The largest farms on the island are operated by **Saltas**, which has established an integrated operation controlling production from the smolt stage through harvesting, processing, and marketing.

III. MARKETING

An estimated 50 percent of cultured Australian salmon are exported fresh/chilled to Japan (figure 3). Exports to the United States are minimal (23 t valued at $170,000in 1991). Attention to quality control has enabled Tasmanian companies to obtain premium prices and secure about 12 percent of the total Japanese imported salmon market. In addition to fresh Atlantic salmon, Australian exporters are moving into valued-added commodities such as smoked salmon, caviar, and patés. There is also interest in producing salmon steaks and fillets using modified atmosphere packaging to extend shelf life.[7]

IV. OUTLOOK

Australia will never harvest salmon on the same scale as Norway or Scotland. Projected future harvests are limited to approximately 5,000 tons.[8] The major limit on Australian harvests is the limited availability of inshore farm sites in Tasmania.[9] For this reason, Australian farmers focus on producing high quality salmon for sale on lucrative gourmet markets.



Source: Salmon Growers Association of Tasmania

Figure 2.--Australia. Atlantic salmon and trout harvests in Tasmania, 1986/87-1991/92.

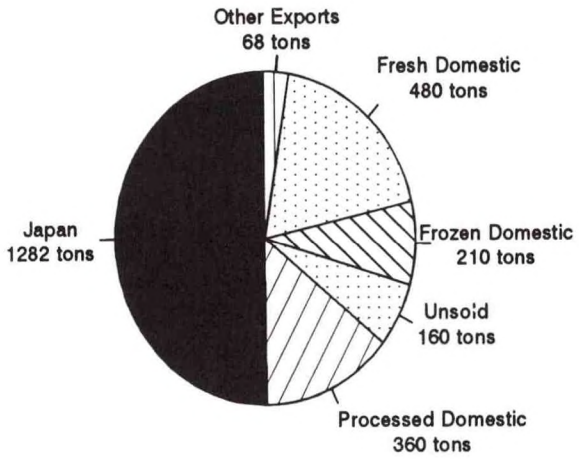


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Figure 3.--Australia. Sales of Tasmanian salmon in 1990-91.

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9. Cooper, *op.cit.*

Chapter XI
Pacific

JAPAN

Japan is the world's largest market for salmon and the largest salmon importer. With its enormous market, Japan has attempted to maintain a high level of self-sufficiency in salmon supplies. With decreasing access to wild North Pacific salmon (highseas salmon fishing was banned in 1992), Japan has turned to coho salmon (*Oncorhynchus kisutch*) culture to supplement domestic salmon supplies. Coho culture in sea cages has increased significantly in recent years, but increased foreign cultured competition makes further expansion unlikely.

CONTENTS

Figure 1.--Map of Japan.

I. GENERAL

A. Overview

Japan's farmed salmon production has increased from 8,000t in 1986 to 27,000t in 1991 (appendix H, table 1 and figure 2), making Japan the world's fourth largest producer of cultured salmon and the largest producer of Pacific species. Unlike most other salmon producing countries, Japan does not export its 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 its import requirements, especially for fresh salmon. Production would have to increase dramatically to completely supply Japan's salmon market: in 1991, Japan imported over 140,000t of fresh, chilled, and frozen salmon (mostly frozen Pacific species).

B. Government policies

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 non-Government 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.[1]

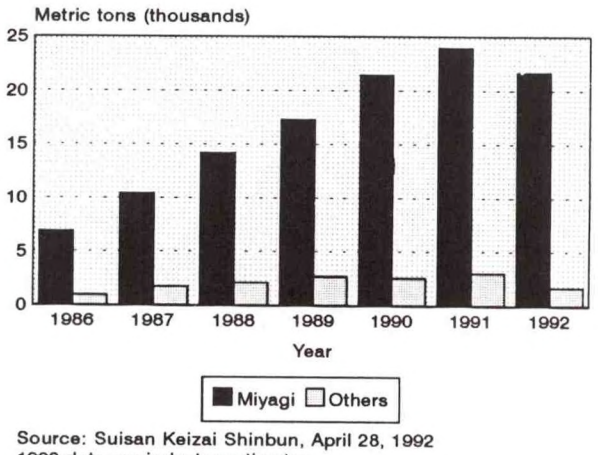
II. PROBLEMS

Competition with imported farmed salmon in 1991 caused the market price for Japanese farmed coho to drop to $3.50 per kilogram, far below the breakeven price of $4.80 per kilogram. This caused some salmon farmers to go bankrupt and discouraged others from continuing salmon culture in 1992. The worldwide salmon glut in 1991 led Japanese farmers to restrain harvests in 1992, with harvests totalling an estimated 23,900t, an 11 percent decrease over 1991.[2]

III. HARVESTS

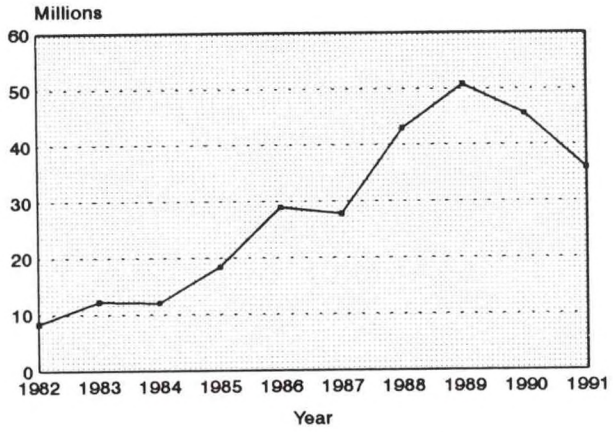
A. Smolts

Licenses are not required to raise coho salmon smolts in Japan. This situation makes it difficult for Japanese Government officials to estimate the total number of smolt farms and smolt production. The Government of Japan estimates there are no more than 100 freshwater smolt farms, using fertilized coho



Source: Suisan Keizai Shinbun, April 28, 1992
1992 data are industry estimates

Figure 2.--Japan. Farmed coho salmon harvests, Miyagi Prefecture vs. other prefectures, 1986-92.



Source: Japan Fisheries Resource Conservation Assoc.

Figure 3.--Japan. Imports of fertilized coho salmon eggs.

eggs imported primarily from the United States (figure 3).[3]

B. Salmon

Most commercial-scale salmon farms in Japan produce coho salmon; smaller farms produce other species including cherry salmon (*Onchorhyncus masou*). There were an estimated 408 coho salmon farms active in Japan in 1991, compared to 326 farms in 1988. Most of these farms (335) are located in Miyagi Prefecture, about 200 miles north of Tokyo (figure 1).[4]

IV. COMPANIES

Nichimo Fishing Corporation, a major Japanese company, built the first Japanese salmon farm in the early 1970s, prompted by the decline in North Pacific salmon fishing quotas. The company has continued to be the leading producer of coho salmon, and has begun to produce cherry salmon and hybrid salmon species, using biotechnology. 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.[5]

V. MARKETING

A. Domestic

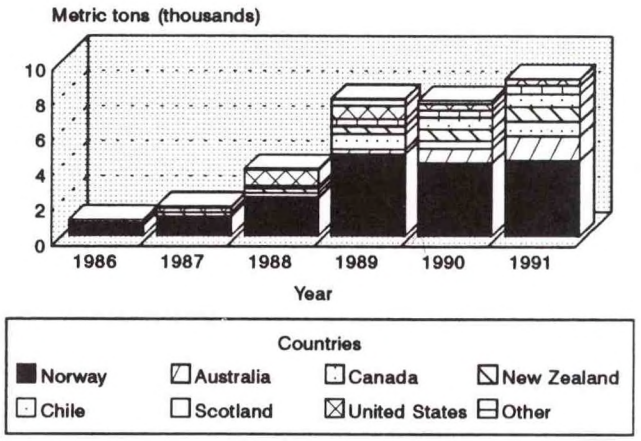
Cultured coho must be marketed in May through early July because they would face price competition from wild Pacific salmon imports from the United States and Canada if marketed later in the year. In addition, cultured coho are sensitive to summer water temperatures above 20 degrees centigrade. The current commodity forms for cultured coho salmon are 60 percent fresh (predominantly fillet), 25 percent salted, and 15 percent frozen.

Japanese consumers generally do not perceive the difference between wild and farm-raised salmon. While fresh cultured salmon, including Norwegian Atlantic salmon and New Zealand chinook salmon, were sold only to restaurants 10 years ago, they are now commonly sold at supermarkets. Demand for processed Japanese cultured coho, such as salted coho, is also increasing. Processed cultured salmon is usually sold the same way as processed wild salmon in Japanese supermarkets. The Japanese cultured coho industry is trying to create a specific market niche for cultured coho by improving its flavor, fat content, and color through the use of improved feed formulas.[6]

B. Imports

1. General

Imports are an important supply source for the Japanese salmon market and accounted for about one-third of the total 1990 Japanese salmon supply. The late 1980s saw a gradual change in the make-up of the Japanese salmon market with fresh imports, primarily cultured, comprising a larger portion of total imports. As recently as 1987, frozen salmon imports comprised 98 percent of the market, but that figure declined to 94 percent in 1991 as the Japanese market became more receptive to fresh imports, primarily from Norway, Australia, Canada, New Zealand, Chile, and Scotland. Japanese trade



Source: Japan Marine Products Importers Association

Figure 4.--Japan. Fresh salmon imports, 1986-91.

statistics do not differentiate between wild and farmed salmon, but it is believed the majority of fresh imports are farmed.[7]

The United States, Canada, Chile, and the former Soviet Union are the major frozen salmon suppliers to Japan. The United States and Canada have been traditional leaders in this commodity, but Chile and the former Soviet Union have replaced former suppliers in North and South Korea. With the exception of Chile, most of this salmon is wild-caught. Imports from the former Soviet Union have increased dramatically as Japanese access to the Soviet EEZ and highseas salmon has been restricted. Dependency on Russian supplies should increase since highseas salmon fishing was banned as of 1992.

2. United States and Canada

The United States and Canada are far and away the largest suppliers of frozen salmon to Japan (U.S.-67 percent, Canada-13 percent in 1991, appendix H, table 2). The majority of frozen salmon imports are wild-caught sockeye salmon (*Onchoryhncus nerka)* whose size and color are preferred by Japanese consumers. Attempts to raise sockeye on a commercial scale have thus far been unsuccessful, so Japan's dependence on U.S. and Canadian supplies will continue.

3. Chile

Chile's remarkably successful cultured salmon industry has enabled it to gain a significant share of the Japanese market in a very short time. Imports of Chilean fresh and frozen salmon totalled just 44 tons in 1986, but increased to over 20,000 t by 1991. The primary species imported is coho salmon, but chinook and Atlantic salmon are also imported. Low production costs have enabled Chilean coho to compete effectively with cultured domestic product. The increasing importance of Chilean supplies was seen in 1988 when the **Nippon Suisan** Company purchased **Salmones Antarctica**, the pioneer Chilean salmon culture company. Other Chilean salmon farmers have indicated they plan to concentrate their export efforts on the Japanese market.[8]

4. Norway

Norway replaced the United States as the primary supplier of fresh Atlantic salmon to Japan in 1984 and has maintained its dominance ever since (figure 4). One of the primary reasons for Norwegian success has been the timing of its shipments. Unlike wild-caught U.S. and Canadian salmon, which are primarily sold during the July-September season, imports from Norway occur between January and April when there is no significant wild-caught competition. The high quality of Norwegian cultured salmon has also helped it secure a preeminent position in the Japanese market.

5. Australia and New Zealand

Australia and New Zealand are two recent entrants into the salmon culture industry who have made big profits in the Japanese market. Australian exports of cultured Atlantic salmon (*Salmo salar*) have steadily increased to the point where Australia is second only to Norway in fresh salmon imports.

New Zealand chinook salmon (*O. tshawytscha*) has also posted steady increases in the Japanese market over the past five years. Chinook has gained greater acceptance in Japan and New Zealand's image as a pollution-free country has also given it a leg up on its competitors.

VI. OUTLOOK

Japanese production of farmed Pacific salmon is expected to remain at 20-25,000 t for the foreseeable future. Coho egg imports from the United States, which largely determine coho salmon production with a 2-3 year lag, declined from 51 million in 1989 to 36 million in 1991. Japanese assistance to Russian salmon hatcheries in the Far East is expected to result in increased harvests of Russian salmon for the Japanese market (see Russia report).

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Appendix H

Japan

Table 1.--Japan. Cultured coho salmon harvests, by prefecture and quantity, 1986-92.

Prefecture	Year						
	1986	1987	1988	1989	1990	1991	1992*
	--Metric tons--						
Miyagi	6,900	10,400	14,200	17,300	21,500	24,000	21,700
Iwate	600	900	1,000	1,100	900	1,400	1,000
Niigata	200	500	700	1,200	1,100	1,200	800
Tottori	60	70	100	100	400	400	400
Mie	40	200	200	200	100	0	0
Ishikawa	40	60	90	60	70	0	0
Fukui	10	40	15	15	1	0	30
Total	7,850	12,170	16,305	19,975	24,071	27,000	23,390

Source: Nikkan Suisan Keizai Shinbun, April 28, 1992.
* - Industry estimate

Table 2.--Japan. Imports of fresh and frozen salmon by country, 1986-91.

Commodity	Year					
	1986	1987	1988	1989	1990	1991
	--Metric tons--					
Fresh						
Norway	588	1,096	2,113	4,672	4,161	4,312
Australia	-	1	111	283	830	1,384
Canada	9	25	212	860	436	850
New Zealand	52	191	245	445	667	823
Chile	11	8	64	36	673	729
Scotland	2	17	94	374	405	497
United States	115	264	908	749	371	357
South Korea	80	20	5	-	-	-
Other	60	48	73	423	198	38
Total	864	1,671	3,285	7,843	7,741	8,990
Frozen						
United States	95,894	94,311	103,706	101,965	115,000	90,660
Canada	15,087	9,429	11,152	19,301	18,900	17,840
Chile	34	20	1,000	3,975	9,900	13,906
USSR	779	2,998	-	2,631	2,723	9,374
China	-	-	60	184	2,581	1,047
New Zealand	-	55	617	519	813	872
Norway	227	356	931	1,305	698	844
Denmark	8	406	208	35	67	152
Sweden	5	305	34	54	20	16
North Korea	1,103	547	12	320	-	-
South Korea	291	554	14	26	-	-
Other	-	40	147	1,453	351	171
Total	113,428	109,020	117,880	131,768	151,053	134,882
Grand Total	114,292	110,691	121,705	139,611	158,794	143,872

Source: Japan Marine Product Importers Association.

Chapter XI
Pacific

NEW ZEALAND

Salmon farming in New Zealand is a relatively new industry. The first salmon sea-pen was established on Stewart Island in southwestern New Zealand (figure 1) during 1982. Many farmers began to raise salmon on a small scale after first operating other aquaculture ventures such as mussel farms. New Zealand's salmon production has increased rapidly in recent years. While it has yet to become a producer on the scale of Norway or Chile, New Zealand's salmon harvests are significant because farmers produce commercial quantities of chinook salmon (*Oncorhynchus tshawytscha*), a species which is not yet farmed on a large scale anywhere else except Canada. Most New Zealand cultured salmon is shipped frozen to the Japanese market. Increased foreign competition and New Zealand Government environmental policy will probably limit expansion of cultured harvests in the future.

CONTENTS

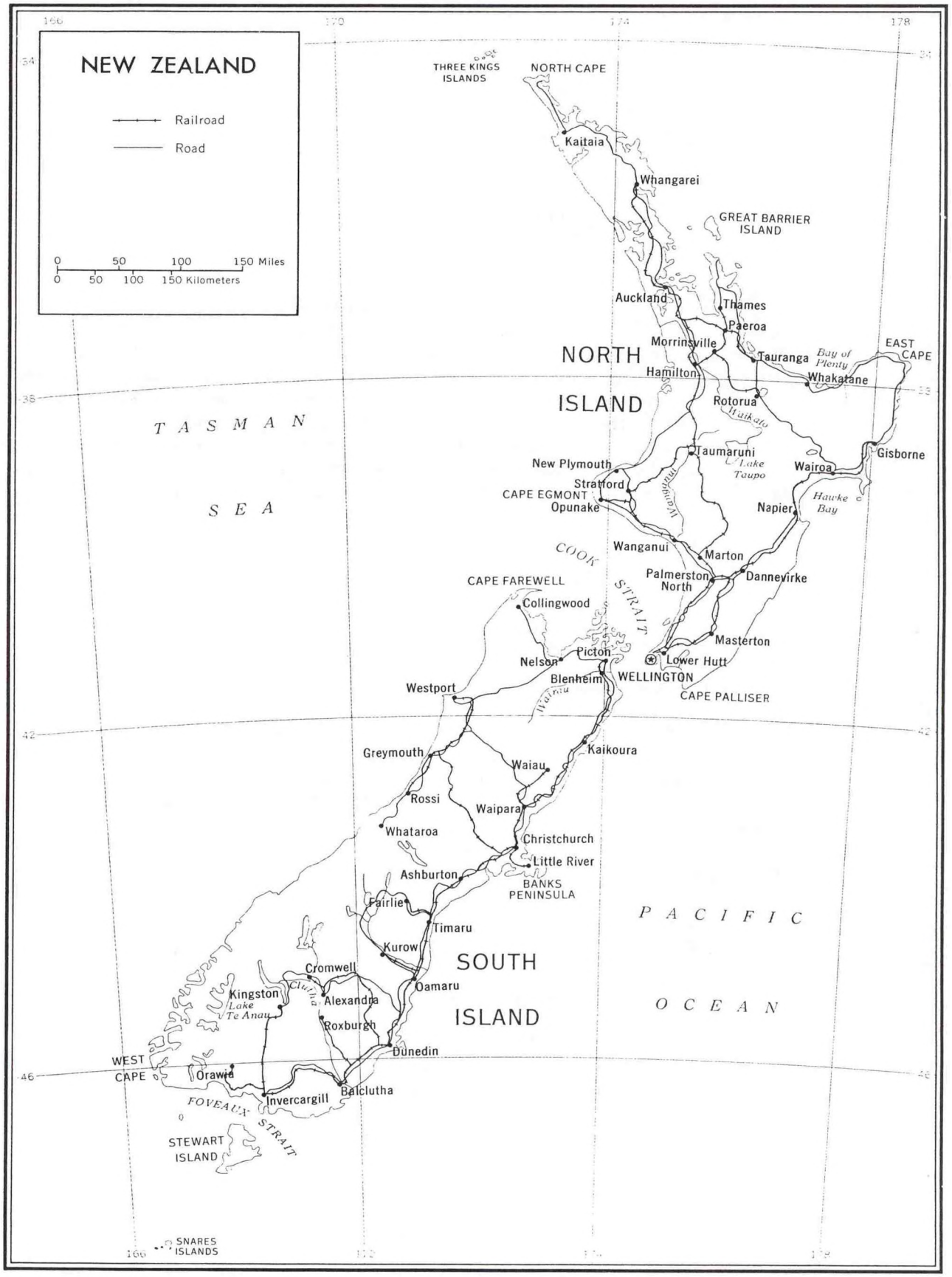


Figure 1.--Map of New Zealand.

I. GENERAL

A. Overview

New Zealand is well suited to mariculture thanks to its abundant unpolluted seawater. Three species have dominated the New Zealand aquaculture industry up to now: Pacific oysters, green mussels, and chinook salmon. Total aquaculture harvests comprised approximately 10 percent of New Zealand's 1989 fisheries catch.[1]

Three species of non-native salmon are present in New Zealand, all introduced from the Northern Hemisphere. Two are Pacific species, chinook and sockeye (*Oncorhynchus nerka*), and the other is Atlantic salmon (*Salmo salar*). Chinook and sockeye were introduced from North America in 1901. Chinook salmon established populations in rivers along the east coast of the South Island and its stock has proven to be the most amenable to aquaculture. There is a good genetic base, and the species is suitable for the three methods of salmon culture practiced in New Zealand; sea-pen, freshwater pond, and sea ranching.[2]

B. Government policies

The Resource Management Act 1991 stipulates the requirements for mariculture in New Zealand. The Act requires the Government to place environmental considerations above all others when evaluating mariculture proposals.[3]

II. PROBLEMS

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 1,400-1,500t of pen-raised chinook salmon) were lost after an algal bloom struck sea-pens in Stewart Island's Glory Bay, the center of the New Zealand salmon farming industry. On that occasion, farmers were allowed to move to other locations on the condition that they return to Glory Bay once danger had passed. After these serious losses, farmers petitioned the Government to allow increased harvests.[4]

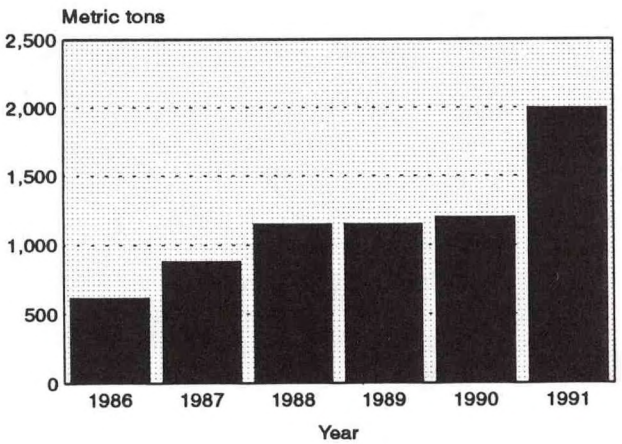
Regulation of salmon farming is a sensitive issue in New Zealand where environmental protection is a national priority. Strict Government regulations have played a leading role in protecting New Zealand's salmon farms from disease outbreaks.[5] On the negative side, however, these regulations have caused long delays as applications for licenses are reviewed.

Apart from regulatory control, another factor in the slow growth of New Zealand's salmon farming capacity is opposition from environmentalists and owners of adjacent coastal land. There is also a shortage of sites suitable for sea-pen rearing. The temperature requirements of salmon limit harvest to the South Island. Research on the use of larger pens offers one potential solution to this problem. Seawater pond farming on land offers another possible solution since salmon can be stocked at higher densities and this method offers more control over environmental conditions than sea-pen farming.[6]

III. HARVESTS

A. Smolts

Most New Zealand salmon culture companies maintain freshwater hatcheries and carry out broodstock programs. Genetic research has been conducted for a number of years in conjuction with the New Zealand Government. Smolt are usually



Sources: FAO, Suisan Keizai Shinbun

Figure 2.--New Zealand. Salmon harvests, 1986-91.

moved into sea-pens during November and December. Mortalities have declined to low levels after the introduction of improved hatchery techniques.[7]

B. Salmon

Exact figures for production by species are not available, but in 1991, New Zealand's salmon farms produced an estimated 2,000t (figure 2) of processed chinook salmon. The maximum capacity of New Zealand farms is an estimated 3,000 t and no increases beyond this figure are expected because of governmental environmental policies.[8]

There are approximately 12 salmon culture operations in New Zealand. Of these, 3 are large companies, and 6-7 are small to medium-sized companies.[9] Most farmers and ranchers raised chinook salmon. There are also 2 freshwater pond farms that produced sockeye salmon[10], but output is at low levels (an estimated 5 t in 1989[11]). Attempts at sea-pen rearing of sockeye salmon have failed.

Approval was granted in late 1991 for a farm which would harvest sockeye in canals built for hydro-electric plants in the central South Island. The farm is opposed by local trout fishermen who fear the introduction of disease.[12] There has been some research done on Atlantic salmon sea-pen culture, but with limited success. The stock used in research reportedly had a poor genetic base.[13] Intense foreign competition for the cultured Atlantic salmon market will probably preclude future New Zealand efforts to culture this species.

Sea-pen culture is the dominant method, accounting for over 90 percent of New Zealand harvests. The first sea-pen culture farm began on Stewart Island in 1982. Juvenile chinook salmon are transferred from freshwater to sea-pens where they are fed high-oil dry pellets and grown to market size.[14] The salmon are fed by hand and locally-developed automatic battery feeders. Feed conversion is estimated at 2:1.[15] Most of the salmon is harvested between October and March, although some farms are able to harvest salmon year-round.[16]

Freshwater pond rearing has attracted the attention of New Zealand farmers who have a suitable supply of freshwater and are interested in diversification. As with sea-pen culture, salmon are grown to market size in captivity, but using freshwater. Several small-scale farms have opened, with annual harvest targets of 5-10 tons. Salmon cultured with this method is usually sold on the domestic market.[17]

IV. COMPANIES

There are three major companies culturing salmon in New Zealand: **Regal**, **Big Glory**, and **Southern Ocean**. The **New Zealand Salmon Company** (NZS) was a major player until 1992 when its aquaculture department was purchased by **Regal**. This purchase makes **Regal** the largest salmon culture company in New Zealand.[18]

A. Regal

Regal Salmon Ltd. first began farming salmon in 1986. The company operates 2 hatcheries, four sea-pen farms, 4 processing plants, and owns a 50 percent share of a salmon feed plant. Regal's current annual harvests are approximately 1,000 t and it hopes to harvest 2,000 t by 1996.

The company has close ties to the Japanese market. Regal signed an exclusive distribution agreement with the **Mitsubishi** Corporation in 1987 and its exports to Japan have increased from 2 t in 1987 to an estimated 600 t in 1992. The company hopes to develop markets in Southeast Asia and Western Europe.

Regal feels its future success lies with marketing "organic" salmon, so it emphasizes the use of environmentally sound techniques. For example, Regal has developed a sea-pen system which is cleaned by the elements rather than man-made chemicals.[19]

B. Big Glory

Big Glory Ltd. farms salmon in the Big Glory Bay of Stewart Island. The company built additional sea-pens and invested $60,000 in new salmon processing equipment in 1991. These investments have paid off as Big Glory has secured a $600,000 contract to export processed salmon fillets to Japan.[20] With expanded farm size and this lucrative contract, Big Glory hopes to increase its harvests from 700 t in 1991 to 900 t in 1992 and 1,050 t in 1993.[21]

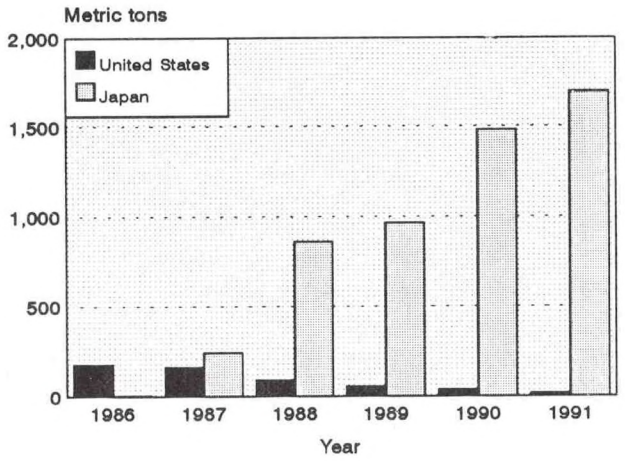
Big Glory's sea-pens are large (averaging 6,300 cubic meters) and built to withstand the gale-force

winds and high waves common to Stewart Island. The company reportedly owns the largest sea-pen in the world which is capable of producing an annual harvest of 150 tons.[22]

C. Southern Ocean

The third-largest New Zealand cultured salmon company is Southern Ocean Salmon, Ltd., a subsidiary of **Salmond Smith Biolab**. Salmond Smith Biolab's purchase of Southern Ocean in 1987 enabled the company increase harvests by nearly 5 times between 1986 and 1989. The company hopes to harvest 450 t by 1992. As with Regal and Big Glory, Southern Ocean exports most of its salmon to Japan.[23]

Southern Ocean has been developing a market for its salmon in Australia. It is the only New Zealand company which has received permission to ship fresh and frozen salmon fillets to the Australian market. The company has high expectations for the Australian market and hoped to export 50 t in 1991. Over time, the company feels Australia can become its second largest market after Japan.[24]



Sources: U.S. Dept of Commerce, Japan Ministry of Finance

Figure 3.--New Zealand. Salmon exports to Japan and the United States, 1986-91.

V. 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 (figure 3). Major Japanese buyers are **Mitsubishi Shoji**, **Nippon Suisan**, and **Nichirei**. In 1991, New Zealand exported nearly 1,700 t, worth $10 million to Japan, but only about 14 t to the United States. Industry observers in Japan estimate 1992 exports to Japan will be approximately 1,400 t (Regal 600 t, NZS 400 t, Big Glory 300 t, and Southern Ocean 200 t). Exports are divided evenly between fresh and frozen product.[25]

New Zealand's southern-hemisphere location is advantageous for salmon exports, because--like Chile-its harvests are available during the northern hemisphere's salmon-culturing off-season (June-August). Furthermore, by producing chinook salmon, New Zealand's farmers have entered a market with limited competition from other salmon farming nations. New Zealand's relative isolation, however, means its salmon exporters must pay high transportation costs.[26]

VI. OUTLOOK

New Zealand cultured chinook salmon is a high quality product which generates considerable revenue on foreign markets. Harvests have increased steadily over the past five years, except in 1989 when algal blooms struck. Future harvests will be constrained by the New Zealand Government's environmental policies and market fluctuations. New Zealand's position as the leader in chinook harvests, however, gives it a special niche in the international salmon market and should encourage a gradual increase in future harvests. The New Zealand salmon culture industry should therefore remain small but lucrative.

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KOREA

Salmon culture in the Republic of Korea (ROK) is still in its formative stages. No harvests have been reported, but the Norwegian company AQUACARE reportedly plans to build a farm on the east coast of Korea which would be able to annually harvest 1,000 tons of Atlantic salmon (*Salmo salar*). Operations were scheduled to begin in September 1991, but no further information is available.

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Chapter XI
Pacific

RUSSIA[1]

Russia's salmon production consists mostly of wild pink, chum, and sockeye salmon caught in the Pacific Ocean off eastern Russia. Small quantities of chinook, coho, masu, and Atlantic salmon are also commercially fished. Because of the importance of this fishery, Russia has operated salmon hatcheries in the Far East since the 1920s and now releases 500 to 700 million salmon fry into the Pacific annually. Russia began promoting salmon hatchery ventures with Japan in an effort to rebuild stocks of wild Pacific salmon. Russia's salmon restocking efforts are almost exclusively hatchery orientated. Russian scientists have been experimenting with raising freshwater and marine species, with some notable success in growing carp, whitefish, rainbow trout, and sturgeons. However, salmon culture is still in its infancy. Russia does, however, have a tremendous potential for raising or ranching salmon in the future. Joint venture salmon farming, possibly with Norwegian investors, appears ready to begin.

CONTENTS

I. GENERAL

A. Overview

Russia's salmon fishing amounted to 121,000 metric tons (t) in 1990 and included 73,000 t of pink, 27,000 t of chum and 16,000 t of sockeye salmon in the Pacific Ocean. Chinook (900 t), coho (2,300 t), and masu (cherry) salmon are less abundant.[2] Russia's Pacific coastline offers suitable conditions for raising salmon. Russia's far eastern region covers about 1 million square miles, comprised of the provinces of Amur, Primoriye, Sakhalin, Magadan, and Kamchatka. The Kamchatka peninsula, Sakhalin, and the Amur region have river systems where salmon have spawned for centuries. Limited catches of Atlantic salmon (1,200 t in 1990) take place in the Baltic Sea. A Russian-Norwegian joint venture salmon farming operation could begin operating in the Arkhangelsk area in the near future.

B. Historic

1. Pacific fishery

Russia's catches of salmon, especially of chum, fluctuate in part because of the periodic shifts in the Kuroshio Current, which causes cooling and warming of east Russian waters. Salmon are more abundant when waters are warmer than during periods of cooler water temperatures.[3] Russian salmon resources were fully utilized, and there were sufficient escapement to sustain the runs into Russian rivers, during the period between 1926 to 1933. Salmon fishing expanded rapidly between 1934 and 1940. Following World War II, only stationary nets and beach seines were used to harvest salmon, and stocks slowly recovered. The Japanese resumed highseas salmon driftnet fishing in 1952. This action decreased Russian salmon catches sharply, because Russian catches now depended on how many salmon escaped Japanese nets to return to their natal spawning grounds.[4] Japanese officials, in consultation with the Soviet Union, has gradually reduced Japanese salmon driftnet fishing over the past 20 years. A moratorium on highseas salmon fishing was initiated in 1992.

2. Atlantic fishery

Russia's Atlantic salmon catch ranged between 900 t and 1,200 t between 1980 and 1990.[5] The Atlantic Ocean and Russia's northwest inland waters provide Russian fishermen access to wild salmon. The Russian salmon catch in this region was 8,500 t in 1989.[6] Russia's major Atlantic salmon waterways include the Neva River and the Narva River (which borders Estonia). The Soviet Union also had access to three important salmon rivers, the Neman and Venta (in Lithuania), and the Daugava (in Latvia);[7] however, because these waterways are part of the now independent Baltic States, the Russians have lost a major source of Atlantic salmon in the Baltic Sea. Russian fishermen also catch Arctic Atlantic salmon in their White Sea and Barents Sea tributaries.[8]

C. Government policies

1. Privatization

During the era of the Union of Soviet Socialist Republics (USSR), all activities relating to salmon fishing, hatcheries, and culture were administered by the Government. The situation following the re-establishment of Russia (and the Commonwealth of Independent States in 1991) has produced considerable changes. In Russia, efforts are underway to privatize what was once a government-owned operation. It is expected that Russian businessmen will soon seek contacts with Western businessmen to establish commercial fish farming operations.

2. Regulatory controls

It is unclear, at this time, what the role of the Russian Government will be in the future of fish farming in Russia. VNIRO, the Department of Conservation and Management (specifically "Glavrybvod," the VNIRO group dealing with fisheries resources, reproduction, enhancement, and hatcheries) is thought to be responsible for fish culture in Russia. That group reportedly has 22,000 employees throughout Russia.[9] The Russians reported that they have instituted measures to conserve Atlantic salmon, prohibiting fishing on the spawning grounds and adjacent to dams. Gear and seasons are closely regulated and a catch limit has been established.[10]

3. Research

The Research Institutes of Fishery Committee of Russia, the Institute of the Russian Academy of Sciences, and various universities will be responsible for research. The Scientific Consultant Mariculture Council of the Ichthyological Joint Committee Commission serves a coordinating function in marine aquaculture and is based in Moscow. Scientists from

the various fishery academies, institutes, and universities are members of the Council.[11] VNIRO also has a Salmon Enhancement Laboratory.[12]

II. HARVESTS

Salmon and sturgeon culture have a long tradition in Russia. Russin aquaculturists have also cultured marine fish (herring, mullet, striped bass, and flatfish), seaweeds (laminaria and gracillaria), mollusks (mussels, oysters, and scallops), crustaceans (crabs), and other species (sea cucumbers) in recent years. Freshwater culture includes raising carp, rainbow trout, and whitefish. Russian salmon culture focuses on raising smolts for restocking efforts, although scientists have also begun experiments with ongrowing.[13] The Food and Agriculture Organization (FAO) of the United Nations reports that Russian aquaculture harvests amounted to 354,200t in 1989, consisting mostly of common and silver carp. The FAO report also noted that Russian fish farmers harvested small amounts of keta and sockeye salmon between 1986-88, but that these harvests were "negligible"in 1989.[14]

A. Hatcheries

1. Pacific

Russia's first salmon hatcheries were constructed in the Far Eastern USSR in 1924 on the Amur and Kamchatka Rivers. The Japanese also built salmon hatcheries on Sakhalin Island and the Kuril Islands in the 1920s. By the beginning of World War II, the Japanese had 12 hatcheries with a capacity of 170 million eggs in the region. The Soviets acquired these islands and the hatcheries on them at the end of World War II. The Soviets restored the war-damaged facilities and built 13 more hatcheries on the islands between 1946 and 1960. This provided the USSR with a total capacity of 265 million eggs for Sakhalin and 100 million for the Kurils. Since 1962, these salmon hatcheries have rapidly expanded output.[15]

Japan proposed establishing joint salmon hatcheries in the Russian Far East as early as 1962. Agreement to establish a joint hatchery was signed 26 years later, on July 12, 1988. Construction was completed in October 1989 at a cost of $12 million. The joint venture, Pilenga Godo, released its first fingerlings in May 1990: 4.3 million chum, 97,000 pink, and 87,000coho salmon fry were released. The hatchery planned to release over 20 million fry in 1991 and 30 million in 1992. Other Russian-Japanese joint salmon hatcheries have been built in the Russian Far East since Pilenga Godo. The Aniva hatchery was established on June 26, 1989 in Sakhalin. Kamchatka Pilenga Godo was established on April 19, 1991 in the Kamchatka region and construction began in May 1992. Nikkeiren hatchery, established in June 1991 in the Magadan region, was the first joint venture approved by the Russian Federation Government following the collapse of the USSR.

Hatcheries in the Kamchatka Peninsula currently produce 80 percent of Russia's total sockeye salmon production. Kamchatcka also has lakes and waterways suitable for salmon rearing.[16] About 30 smolt hatcheries currently operate in Russia, producing around 1 billion salmon fry (pink, chum, sockeye and Atlantic salmon) last year. Normal production ranges between 500 million and 700 million smolts annually, however.[17]

2. Atlantic

The USSR also built hatcheries to stock Atlantic salmon in streams leading into the Baltic. The Soviets claimed that they can rear seagoing smolts in eight months (compared to two years in Sweden) through the use of specially prepared feeds.[18] The Russian USSR has been raising and releasing about 3 million salmon smolts into the Baltic and Black Seas annually. It is not known if the new Russian Government will continue this tradition.

B. Salmon

Russian scientists and farm operators are successfully raising rainbow trout (*Salmo gairdnerii*), steelhead trout (*Oncorhynchus mykiss*), sea trout (*Salmo trutta*), and arctic char (*Salvelinus alpinus*) in the Barents, Baltic, and White Seas, and recently in the Black and Caspian Seas. Dr. L.A. Dushkina, Chief of the Mariculture Laboratory at VNIRO in Moscow, reports that Russia is now culturing Atlantic salmon on an experimental basis. She reports that *"Salmon cultivation in salt water includes rearing in ponds, isolated lagoon, cages, and in commercial re-circulated systems."* This reference applies primarily to various trouts and probably to only small quantities of Atlantic or Pacific salmon:[19] the FAO reported Soviet harvests of cultured keta salmon as 4 t in 1986, 10 t in 1987 and 9 t in 1988. The FAO also reported 1 t of sockeye salmon

harvested in 1986 and 2 t in 1988.[20]

1. Grow-out

The winter climate in Russia's Far East is severe, except in the Sakhalin and Primorskii regions. Ice covers ponds for 4 to 6 months a year making salmon culture difficult.[21] Again, FAO indicates that salmon grow-out experiments, using keta and sockeye salmon, have been conducted in both the Far East and Baltic regions of Russia. Russian culturists are probably conducting other such experiments, possibly on a less formal basis. These grow-out experiments should provide Russian aquaculturists the experience they need to begin commercial salmon farming, if they choose. Leaders of Norway's Finnmark Province parliament and the Arkhangelsk Oblast signed a 1992 agreement with Norwegian investors to establish salmon farms, fish factories and fish nurseries, and feed production enterprises.[22]

2. Ranching

The prospects for salmon ranching in Russia are excellent. Russians have released millions and millions of salmon fry into Russian rivers over the past 60 years. Soviet scientists transplanted millions of pink and chum salmon eggs from Murmansk to the Far East and established a new run of Pacific salmon to the eastern Atlantic and northern seas.[23] It is not known if scientists designed these experiments simply to increase the harvest of wild fish in the ocean, or if efforts were made to harvest the fish upon their return to their natal steams. Regardless of where they were harvested, Dr. L.A. Dushkina at VNIRO notes that Russia normally releases 500 to 700 million salmon fry annually and has the capacity to produce 1 billion fry annually. Russia, thus, has the skill, knowledge, and hatcheries to begin a massive salmon ranching operation. However, it lacks the infrastructure and marketing skills needed to deliver high-quality, freshly-harvested salmon from rugged, isolated areas to distant markets. If these problems can be solved, then the prospect for future salmon ranching in Russia appears quite good.[24]

III. OUTLOOK

The outlook for salmon farming in Russia's Pacific waters appears positive. Salmon thrive in these waters and the Russians have slowly established a network of hatcheries that could be used for ranching or to provide salmon farms with smolts for on-growing. Russia's Pacific coast has ample room for salmon farms, and environmental impacts will probably not be a major concern at this time. Russia desperately needs to develop commercial ventures, and salmon farming appears a likely candidate for development. Russia has low labor costs and many kilometers of clean waters to raise fish. They also have access to inexpensive pelagic fish that can be used in salmon feed. What the Russians lack, at the moment, are joint venture partners able to provide the cash and technical knowledge to begin operations, and the skill to market the harvests.[25] Because most factors are favorable, however, it would not be surprising if Russian salmon culturists harvested farm-raised salmon by 1995. This is, of course, provided that the country remains stable and committed to private market development. Russian production will probably focus on Pacific species and Atlantic salmon raised in the Pacific Ocean. It is less likely that the Russians will be able to farm significant quantities Atlantic salmon in the Baltic Sea, primarily because of problems with pollution, low salinity levels, and the independence of the Baltic States. Opportunties in the White, Black, and Caspian seas exist, and with the assistance of joint venture partners, could become sites for future salmon farms.

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23. E. Evan Brown, *World Fish Farming: Cultivation & Economics,* AVI Publishing Company, Westport, 1977, p.227.

24. Although prospects for ranching appear quite good, there are many difficulties that need to be overcome, including building roads and airports, obtaining permits, etc. Many investors have found it difficult to begin successful commercial ventures in Russia. For additional details see; "Territorial Survey of the Russian Far East," A special issue of *Russian Far East Update,* published by the Russian Market Information Services, P.O. Box 22126, Seattle, WA 98122.

25. Russia also lacks many important infrastructure features in the remote Far Eastern areas. The Russian administration also lacks many of the banking, regulatory, and other services needed to maintain a modern operation. This situation, however, will improve given time. For additional details see; "Territorial Survey of the Russian Far East," A special issue of *Russian Far East Update,* published by the Russian Market Information Services, P.O. Box 22126, Seattle, WA 98122.

Conclusions

VI. CONCLUSIONS

World harvests of cultured salmon have continued to increase, despite declining profits. This can be attributed in part to the long investment/return period involved in salmon culture: smolts purchased today will come to market in two years. Because the market outlook was bright during 1989, salmon farmers placed a great number of smolts into grow-out pens. Those smolts came to market during 1991. Smolts placed into grow-out pens during 1990, however, were released during a declining market; consequently, harvests during 1992 should be lower. Norway's harvest of farmed salmon during 1992, for example, should decline to about 120,000 t because of reduced smolt production. Following this logic, harvests should continue to be lower through 1993. By 1994 or 1995, however, harvests should once again begin to increase, especially if prices recover and markets can be expanded. Thus, Norway's harvest could reach 200,000 t by 1995 based on moderate growth rates. This would push world harvest up to levels approaching 400,000 tons.

When salmon farming began, competition was low and profits were high. Farms could afford to operate inefficiently and with high stock losses. Farmed salmon was a rarity and sold for premium prices. As the industry grew, however, competition became more intense and prices declined. The restructuring of the salmon farming industry has eliminated many of the marginal or inefficient producers. The salmon farms that remain today are more integrated, more efficient, and better able to produce large quantities of salmon at a profit. This will also contribute to increased growth during the 1990s.

The salmon farming industry should evolve in new directions in the next few years, including:

Coastal farming should decline in importance because coastal sites are becoming scarce and there is intense competition with other industries (tourism, etc.) for those areas. **High-seas** farming will increase in importance, especially as the marine industry is able to manufacture equipment designed to withstand severe weather. **On-shore** tank culture could become more prevalent if the high costs associated with this form of farming can be overcome. Ocean ranching remains an illusive possibility. Russia appears to have the best potential for **ocean ranching**, provided high-seas fishing can be regulated. Most nations cannot control fishing of "their" ranched salmon and thus returns remain uncertain. Iceland and Chile has small ranching operations underway with modest returns. Russia has the capacity of becoming a major salmon ranching nation.

Salmon will be altered through better breeding and nutritional studies. Faster growing salmon able to utilize feedstuffs more effectively should lower production costs and pollution problems. Future fish will be more resistant to stress and disease and scientists will be able to control fat content and flesh color to a greater degree.

Many **investments** were made in salmon farms which were poorly run or inefficient during the formative years of the industry. Many investors failed to anticipate the dangers of overproduction and also failed to act quickly to reduce their exposure when prudence dictated a sharp reduction in expenses. Investors and bankers continue to misread to industry; they should now be investing capital in salmon farming in anticipation of good returns in 1994-95.

Science can offer many solutions to the problems facing the industry, but some of the best solutions are "natural" solutions, such as building deeper holding pens to allow salmon to avoid sea lice instead of creating new chemical treatments to kill sea lice once infestation occurs.

Quality control will be an important key to future salmon markets. Salmon from different producers command different prices based on consumer perceptions of quality and the reputation of the producer. Achieving this consumer image for quality will be crucial to expanding markets during the 1990s. The efforts of the Scottish smokers to protect their image, for example, is an important program. Use of gill tags and other marketing strategies, such as the appeal to "white tablecloth" consumers will also be necessary for expanding the market among more affluent consumers.

Value-added salmon products will play a more important role in the next decade. The majority of today's exports consist of fresh, gutted, heads-on salmon. The future, however, will increasingly require finished seafood dishes, including salmon fillets, steaks, and portions prepared for home consumption. If salmon farmers plan to increase

harvests, they must expand their markets: new products for home consumption can tap a high growth market.

Harvests could easily approach 400,000 t before 1995. Norway alone could produce 400,000 t of cultured salmon! Thus world production could easily be expanded, and the events of the past few years show that increasing production will continue. The question is not the ability of salmon farmers to produce fish, but rather their ability to profitably market what they harvest.

Marketing remains the key to the future. Although the salmon industry has the technical capability to produce huge quantities of salmon, it does not have the marketing infrastructure to market these quantities of salmon profitably. The industry must also create the demand (which is out there) for their products at profitable prices. It will be the challenge of the next few years to develop these marketing channels.

Despite many positive factors, there are also a few negative issues that must be faced by salmon farmers.

The bankruptcy of the Norwegian Salmon Farmers Sales Organization (FOS) ended the dominant role of the **single marketing structure**. A single marketing structure can better track sales of smolts to its members, total planned production, and thus control the expansion of markets. The failure of the FOS, however, underscores the frailty of this "control" and underlines the danger of relying on one single marketing association. Another argument against this type of organization is that it is a monopoly that frequently inhibits the development of an industry. Many salmon farmers prefer their "own" structure and do not wish to be a part of a larger sales organization. This dichotomy is likely to remain in place during the 1990s, despite a recognized need for common marketing approaches.

There is a commonly recognized need for **generic marketing** of salmon. This approach would benefit all producers, but is also likely to be strongly resisted by different companies and countries. In many instances the real competition is not other salmon producers, but meat and poultry producers which are competing for scarce consumer currency. Generic marketing could help the salmon farming industry compete more effectively for these dollars, yen, pounds, or marks, but this is unlikely to happen in the near future.

The salmon farming industry misjudged citizens' concerns over **environmental issues**. Consumer complaints about the use (some say misuse) of anti-foulant paints, sea lice treatments, and medications, for example, were ignored rather than faced. Today citizen opposition limits the growth potential of the industry in some countries.

Trace elements of **chemical residues** in farmed salmon are likely to attract increasing attention in the next few years. This includes trace elements of chemicals, antibiotics, and feed additives. The EC market, in particular, is enacting stricter import regulations dealing with additives and the United States is likely to enact stricter regulations in the face of growing consumer concern over seafood issues. The use of certain antibiotics or feed additives common today might not be permitted (or could be more strictly controlled) in the future.

Overproduction and **lower prices** can always reappear in the future as companies compete for markets. Cutthroat competition and bankruptcies are common in the airline industry in the United States and price wars occur frequently. There is nothing sacrosanct about the salmon industry, and similar competition should be anticipated in the future. The salmon farming industry can also be affected by landings of wild Pacific salmon, which have been high in recent years. The entry of new players, such as Russia, could also upset plans to develop new products and expand markets. In the end, the marketplace will dictate the future direction of the industry.

In summary, the industry has gone through 3 years of difficulty and many companies were driven into bankruptcy. The companies that remain are leaner and more integrated. They have survived during a difficult market and should now be in a position to take advantage of a good market. Chile is one country that appears to be poised to grow rapidly in the next few years. Norway, following a period of some further consolidation, should begin to produce quantities exceeding 200,000 t before the end of the decade. If Chile, Canada, Japan, and the UK continue to expand their production, world harvests could approach 500,000 t before the turn of the century.

Glossary

GLOSSARY OF TERMS, ACRONYMS, AND ORGANIZATIONS.

Alevin: newly hatched salmon which is still attached to its egg mass. The alevin remains in the stage, using up the nutritional store in the egg sacs.

Anadromous fish: fish born in freshwater, descend into the sea to grow to maturity, and then return to spawn in freshwater rivers and streams.

Atlantic salmon: (*Salmo salar)* belongs to the genus *Salmo* of the *Salmonindae* family. Atlantic salmon generally remain alive after spawning unlike Pacific salmon which usually die shortly after spawning. Characterized by firm, deep-red flesh and spotted-silver skin. Naturally occurring across Northern Europe and North America. Wild stocks of this fish species are threatened by overfishing and habitat loss.

BKD: bacterial kidney disease.

Broodstock: sexually mature male and female salmon used to produce fertilized eggs. Both male and female are selected for desirable characteristics which will be passed on to future generations.

Cherry salmon: (*O. masou*), a Pacific salmon normally raised in Japan.

Chinook salmon: (*Oncorhynchus tshawytscha*), or king salmon, a Pacific salmon that generally weighs about 10 kgs at maturity, but can exceed 50 kilograms.

Chum salmon: (*O. keta*), or dog salmon, a Pacific salmon, that generally weighs about 4 kgs.

Cleaner fish: a small fish, typically of the wrasse family, that consumes sea lice and other organisms from fish. This is a natural method of cleaning fish without the risks associated with the use of toxic or other medications.

Cock fish: male salmon ready to spawn.

Coho salmon: (*O. kisutch*), or silver salmon, a Pacific salmon that generally weighs about 5 kgs.

Culling: the process of removing undesirable salmon during any part of the growth process because of size, poor health, or sexual maturity.

Dipping: the method used to treat fish infected with sea lice. The fish is netted and placed into a container filled with a chemical treatment (such as Nuvan) which kills the lice. After "dipping" the salmon is returned to its pen. The process is similar to dipping animals to rid them of fleas or ticks.

Dog salmon: (*O. keta*), or chum salmon, a Pacific salmon, that generally weighs about 4 kgs.

Egg mass: the yolk sack which newly hatched salmon retain and use for nutrition until they grow old enough to take food from their environment. See alevin.

Eyed eggs: the state in the development of a fertilized salmon egg in which the eyes are clearly visible. The salmon is still at an early larval stage when the eyes are first visible.

Fingerlings: Pacific salmon at the parr stage of development.

FOS: Norwegian Fish Farmers Sales Organization. Established in 1978 with the sole responsibility for marketing farmed salmon. Also abbreviated as NFFSO.

Fry: the third freshwater stage of salmon development, when the egg mass is no longer present and the fish develops characteristic marketings. Salmon typically become fry about 1 month after hatching.

Furunculosis: a salmon disease caused by the bacteria *Aeromonas salmonicida.*

Gill tags: small metal tags that are clipped to the gills of salmon before they are sent to market. The tags identify the country of origin and the quality of the fish. An important marketing tool used to create consumer demand for a specific country's products.

Green eggs: fertilized eggs.

Grisle: Atlantic salmon which become sexually mature after only one year at sea, rather than two years. Grilse occur naturally and account for about 1/3 of a salmon population. Fish farmers do not want early maturing fish, so broodstock are selected to lower the occupance of grisle in aquaculture communities. See also: Jacks.

Grow-out: a term used to identify the stage when smolts are placed into enclosed pens for their final period of growth. These pens can be located in land-based systems or out at sea.

Gutted weight: the weight of a salmon following harvesting and after the intestines and stomach have been removed.

Harvests: the taking of smolts for sale to fish farmers or the gathering of market-sized adult salmon from culture pens for sale to the public (see also production). Harvest figures are usually based on "live weight" before the fish is gutted for shipment to the market.

Hen fish: female salmon ready to spawn.

Hitra disease: a salmon disease caused by a cold-water vibriosis. The disease first appeared in 1984 and is named after a Norwegian island.

Humpback salmon: (*O. gorbuscha*), or pink salmon, a Pacific salmon. A Pacific salmon that weighs about 1 kg. An abundant wild salmon species frequently used for canning.

Jacks: male Pacific salmon that mature after only one winter in the sea and return to their natal rivers to spawn. See also: Grilse and Jennys.

Jennys: female Pacific salmon that mature after only one winter in the sea and return to their natal rivers to spawn. See also: Grilse and Jacks.

Kelts: Atlantic salmon or steelhead trout which remain in freshwater following spawning in the fall. The kelts remain in freshwater over the winter and return to the ocean in the spring.

Kg: kilogram (2.2046 pounds). There are 1,000 kilograms per metric ton (t).

King salmon: (*Oncorhynchus tshawytscha*), or chinook salmon, a Pacific salmon, a Pacific salmon that generally weighs about 10 kgs at maturity, but can exceed 50 kilograms.

Live weight: the weight of a living salmon. (see gutted weight).

Market-size: salmon harvested according to the demands of processors and other consumers. Cultured salmon are harvested before sexual maturity because of the rapid degeneration of flesh quality following the development of sexual organs. See also: Pan sized.

Norwegian Fish Farmers' Association (NFFA): an industry organization to promote salmon aquaculture in Norway.

Nuvan: a chemical treatment used to rid sea lice infecting farmed salmon. The active ingredient in this product is dichlorvos. Recently renamed Aquaguard.

Ocean ranching: the release of farm-raised smolts into the wild. The smolts will feed in the ocean (thus avoiding the high cost associated with artificial feed) until they mature and return to their native rivers. At that point the salmon are harvested. Harvest of "ranched" salmon is not predictable and harvests can only be made when the salmon return to their place of birth to spawn. See also: pen culture.

Pacific salmon: members of the genus, *Oncorhynchus*, within the *Salmonindae* family. Pacific salmon normally die after spawning, unlike Atlantic salmon. There are 7 species of Pacific salmon commonly fished or cultured, including steelhead trout.

Pan sized: a market-sized Pacific coho or chinook salmon designed to appeal to certain markets. The "pan sized" fish is designed to be easily cooked in a pan. Pan-sized salmon generally weigh between 500 to 700 grams.

Parr: the fourth freshwater stage of salmon development, when a characteristic "thumbprint" mark appears on the fish's sides and lateral stripes develop. The last developmental stage before salmon become adapted to the saltwater stage of their lifespan. Pacific salmon at this stage are commonly called fingerlings.

Pen culture: the rearing of salmon in enclosed pens (or cages) in fresh or saltwater environments. Salmon smolts are usually grown in freshwater facilities prior to "smoltification" which prepares them for life in a marine environment. Pen culture requires careful attention to living conditions and requires feeding of the salmon. The harvest of the salmon is predictable and harvests may be determined by market demand, regardless of the season. See also ocean ranching.

Pink salmon: (*O. gorbuscha*), or humpback salmon, a Pacific salmon that weighs about 1 kg. An abundant

wild salmon species frequently used for canning.

Production: all phases of salmon culture, from eggs to smolts to mature fish. The term includes the cost of medicines, feed, labor, etc. The term is designed to cover all aspects of fish farming and not simply the final act of harvesting.

Rainbow trout: (*O. mykiss*, formerly *Salmo gairdneri*), or steelhead trout. Rainbow trout are usually associated with freshwater, in both their wild and cultured states. Steelhead trout are rainbow trout that have been raised in a saltwater environment.

Ranching: the release of farm-raised smolts into the wild. The smolts will feed in the ocean (thus avoiding the high cost associated with artificial feed) until they mature and return to their native rivers. At that point the salmon are harvested.

Redd: a nest in the gravel where the famale lays her eggs.

Red salmon: (*O. nerka*), or sockeye salmon, a Pacific salmon, , a Pacific salmon that generally weighs about 3 kgs..

S_1: a method of identification usually used in Britain to identify one-year old smolts that are generally raised in warm water and mature quickly.

S_2: a method of identification of two-year old smolts that are generally raised in colder water and mature more slowly than S_1smolts.

Salmon trout: a name sometimes used to identify steelhead trout. The name frequently causes confusion among consumers and generally is not accepted in the United States and in some other countries. Now that steelhead trout has been classified as a salmon, however, it is possible that this name may gain acceptance.

Sea lice: small crustaceans *(Lepeophtheirus)* that attach themselves to salmon and feed on their flesh. This produces an unsightly blemish and efforts by the fish to rub the irritant may lead to infections.

Sea trout: a name commonly used in Europe for brown trout (*Salmo trutta*) that is a popular sportsfish, especially Ireland. Sportsfishermen are concerned that salmon farms may be adversely impacting wild sea trouts in some parts of Europe.

Silver salmon: (*O. kisutch*), or coho salmon, a Pacific salmon, a Pacific salmon that generally weighs about 5 kgs.

Smoked salmon: a process that uses salmon, salt, and brown sugard. Traditional smokers use a 16-hour dry salt cure. After curing the sides are hung in kilns where they are smoked for approximately 16 hours. Methods and temperatures can vary according to tastes.

Sockeye salmon: (*O. nerka*), or red salmon, a Pacific salmon that generally weighs about 3 kgs.

Steelhead trout: (*Oncorhynchus mykiss*, formerly *Salmo gairdneri*), or rainbow trout. The steelhead is a rainbow trout that has been raised in a saltwater environment.

Smolt: a young salmon that is ready for life in a saltwater environment.

Smoltification: the complex process that prepares the young salmon for life in a saltwater environment. The smoltification process includes changes in the shape, color, and density of the parr. During smoltification the parr lose their juvenile markings which are replaced with a bright, silver skin. The changes also include behavioral changes as the fish changes from one that prefers to swim against the current to preferring to swim in the same direction of the current and in shoals.

t: metric tons (2,204 pounds). There are 1,000 kilograms per metric ton.

Triploid: a genetically developed sterile salmon.

Whirling disease: a disease caused by infectious pancreatic necrosis.

White tablecloth markets: restaurants catering to wealthier clients. Characterized by the use of white tablecloths. An important market for salmon exporters.

Yersiniose: red-mouth disease, an infection affecting salmon.

SUPPLEMENTARY SECTION

This section contains information that arrived after the publication was completed and sent out for printing. This information, although late, was considered useful and is included as part of the report.

Section A

United Kingdom (Scotland)

Table A1.--United States. Imports of fresh salmon from the United Kingdom, by quantity, 1982-91.

Month	Fresh salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	0	0	136	17,362	34,414	29,694	14,739	33,944	88,046	37,813
February	0	0	2,848	43,911	20,920	44,058	17,276	63,645	60,450	39,810
March	0	766	1,940	51,475	35,011	81,219	30,590	64,074	75,982	89,680
April	0	223	9,485	33,652	58,424	139,102	72,471	128,743	180,774	165,626
May	0	45	7,261	48,052	61,910	79,736	42,796	124,176	102,966	298,341
June	0	41	11,601	48,545	45,961	59,596	48,377	149,711	79,618	306,824
July	0	314	11,107	28,683	11,037	26,308	23,714	84,193	66,515	156,312
August	45	161	5,340	19,543	12,744	19,161	17,505	87,135	62,807	109,027
September	0	222	3,622	34,024	13,838	16,955	13,382	76,974	62,223	39,612
October	0	80	15,297	32,326	19,561	19,635	31,754	70,547	62,821	23,659
November	0	1,167	11,778	17,471	22,887	24,759	32,222	109,464	27,611	13,009
December	0	1,051	23,455	17,398	29,966	24,532	31,953	128,277	54,028	20,710
Total	45	4,070	103,870	392,442	366,673	564,755	376,779	1,120,883	923,841	1,300,423

Source: U.S. Bureau of the Census.

Table A2.--United States. Imports of fresh salmon from the United Kingdom, by value, 1982-91.

Month	Fresh salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	0	0	1,105	130,486	275,847	225,954	180,047	315,476	673,263	284,439
February	0	0	32,161	342,977	176,829	332,336	190,372	495,790	463,136	275,980
March	0	6,141	13,849	379,117	283,030	577,759	291,841	505,509	602,614	625,962
April	0	1,283	69,484	265,898	466,578	1,150,309	685,577	997,689	1,305,042	998,895
May	0	495	51,835	382,025	471,108	691,264	420,395	922,117	792,907	1,727,700
June	0	333	93,555	293,757	361,933	553,633	467,269	1,035,013	555,642	1,825,983
July	0	1,979	82,558	216,274	87,137	227,152	251,740	621,564	493,993	895,135
August	575	1,118	40,912	157,456	95,587	170,437	187,775	646,899	436,025	625,876
September	0	1,611	28,485	277,494	101,168	158,558	146,431	560,644	432,047	235,537
October	0	675	124,563	264,903	153,088	199,076	266,283	515,774	434,089	176,197
November	0	9,964	91,400	147,709	194,360	255,564	259,402	758,757	217,926	88,917
December	0	9,253	182,728	145,277	232,084	269,824	269,408	865,572	381,304	138,388
Total	575	32,852	812,635	3,003,373	2,898,749	4,811,866	3,616,540	8,240,804	6,787,988	7,899,009

Source: U.S. Bureau of the Census.

Table A3.--United States. Imports of frrozen salmon from the United Kingdom, by quantity, 1982-91.

Month	Frozen salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	0	6	45	373	2,414	5,912	0	0	3,270	114
February	83	0	0	0	0	2,512	0	3,294	4,021	218
March	0	0	0	0	0	0	0	216	9,100	136
April	0	0	1,208	0	0	0	0	0	10,859	12,512
May	0	0	0	0	0	0	0	0	2,386	98
June	0	0	0	0	202	0	0	0	0	0
July	0	0	0	0	0	0	0	0	4,379	163
August	0	132	756	0	128	0	0	99	17,528	0
September	0	0	779	697	0	112	0	387	16,251	0
October	0	0	0	679	99	177	0	0	5,308	92
November	0	0	0	4,858	0	0	0	0	6,764	0
December	0	0	938	4,457	105	0	0	4,673	273	120
Total	83	138	3,726	11,064	2,948	8,713	0	8,669	80,139	13,453

Source: U.S. Bureau of the Census.

Table A4.--United States. Imports of frozen salmon from the United Kingdom, by value, 1982-91.

Month	Frozen salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	0	255	470	7,665	0	39,945	0	0	24,002	3,578
February	1,581	0	0	0	36,199	15,832	0	20,175	22,368	1,886
March	0	0	0	0	0	0	0	4,197	62,227	3,928
April	0	0	18,189	0	0	0	0	0	83,316	60,612
May	0	0	0	0	0	0	0	0	22,954	3,346
June	0	0	0	0	3,471	0	0	0	0	0
July	0	0	0	0	0	0	0	0	30,205	1,271
August	0	2,229	10,876	0	3,045	0	0	2,653	134,391	0
September	0	0	11,482	9,614	0	3,578	0	9,282	121,711	0
October	0	0	0	9,142	2,932	5,866	0	0	45,030	3,344
November	0	0	0	13,643	0	0	0	0	56,848	0
December	0	0	13,000	83,606	3,036	0	0	27,035	7,629	3,191
Total	1,581	2,484	54,017	123,670	48,683	65,221	0	63,342	610,681	81,156

Source: U.S. Bureau of the Census.

Table A5.--United States. Imports of smoked salmon from the United Kingdom, by quantity, 1982-91.

Month	Smoked salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Kilograms									
January	3,190	10,036	15,932	13,860	7,618	1,637	632	6,237	11,589	5,533
February	3,011	4,142	6,239	10,030	10,076	3,267	2,864	8,392	9,250	13,317
March	4,746	6,071	6,195	10,973	6,060	6,089	3,542	8,940	14,710	11,064
April	1,612	4,278	8,321	5,313	6,742	6,378	5,180	9,814	15,563	12,636
May	13,498	5,827	10,819	10,335	7,201	7,738	1,608	10,722	23,849	19,695
June	3,953	4,537	6,608	8,894	5,477	2,663	2,522	8,501	11,306	14,534
July	5,985	8,137	12,560	8,541	6,182	4,119	1,986	7,406	13,288	7,837
August	4,468	5,226	6,666	6,338	3,799	4,702	3,576	9,016	12,600	11,524
September	4,574	5,392	9,959	8,856	4,240	3,385	4,392	17,694	29,727	15,407
October	5,658	4,771	13,502	9,689	5,636	5,237	5,231	20,400	17,314	22,708
November	10,166	8,903	13,079	10,865	8,749	9,646	9,503	25,095	32,973	14,918
December	6,311	8,671	20,368	11,133	6,915	7,205	4,831	31,813	27,697	26,756
Total	67,172	75,991	130,248	114,827	78,695	62,066	45,867	164,030	219,866	175,929

Source: U.S. Bureau of the Census. Note: Smoked salmon from the UK presumably includes wild, caught salmon during the early years and imported salmon that was smoked in Scotland and then exported in later years.

Table A6.--United States. Imports of smoked salmon from the United Kingdom, by value, 1982-91.

Month	Smoked salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1.00									
January	64,810	212,267	279,348	242,350	161,853	37,909	17,650	159,630	224,100	128,061
February	66,924	75,521	109,232	162,132	200,716	70,786	64,980	187,798	168,017	260,630
March	94,201	101,484	105,169	183,934	122,191	110,556	86,596	203,787	297,926	223,476
April	37,028	77,330	131,019	84,923	134,212	125,173	114,479	210,058	273,318	250,665
May	185,203	102,556	184,754	172,909	162,974	152,814	41,092	203,903	438,728	304,224
June	87,632	84,216	104,712	142,718	118,669	56,677	60,851	186,126	218,018	250,868
July	105,447	98,501	192,649	151,695	126,283	83,322	49,871	131,014	243,949	141,660
August	87,326	91,394	105,599	120,721	76,215	106,356	85,432	173,924	266,284	214,102
September	89,067	99,383	165,442	154,775	84,648	76,219	104,128	348,907	560,818	303,215
October	109,902	85,796	228,514	173,656	113,155	129,429	115,710	439,224	394,247	398,263
November	160,138	159,518	234,995	212,586	171,342	257,010	229,887	523,709	673,930	234,341
December	122,272	161,724	345,658	243,085	156,465	196,338	136,112	646,916	575,857	485,050
Total	1,209,950	1,349,690	2,187,091	2,045,484	1,628,723	1,402,589	1,106,788	3,414,996	4,335,192	3,194,555

Source: U.S. Bureau of the Census. Note: Smoked salmon from the UK presumably includes wild, caught salmon during the early years and imported salmon that was smoked in Scotland and then exported in later years.

Section B

United States

Table B1.--United States. Imports of fresh salmon, from major salmon producing countries, 1982-91.

Country	Fresh salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Metric tons									
Canada	1,937	1,911	2,522	1,461	2,480	3,855	6,460	20,695	21,637	28,342
Chile	11	-	32	145	679	839	1,175	2,068	7,382	11,260
U.K.	-	4	104	392	367	565	377	1,121	924	1,300
Iceland	-	-	5	5	54	79	325	478	1,016	750
Norway	480	1,768	3,888	6,260	8,854	7,641	8,930	11,613	7,804	560
Faroes	-	-	-	-	-	-	-	478	53	491
Ireland	-	-	-	13	21	47	310	427	356	368
Australia	-	-	-	-	3	1	1	5	13	23
New Zealand	-	3	10	98	161	133	91	55	75	15
France[1]	1	2	1	33	20	2	-	-	1	2
Finland[2]	1	4	82	45	11	1	-	15	-	1
Japan	-	-	-	135	-	-	-	-	-	-
Sweden[3]	4	1	2	8	14	65	3	1	4	-
Sub-total	2,434	3,693	6,646	8,595	12,664	13,228	17,672	36,956	39,265	43,112
Other[4]	44	25	179	148	255	422	126	222	134	143
Total	2,478	3,718	6,825	8,743	12,919	13,650	17,798	37,178	39,399	43,255

Source: U.S. Bureau of the Census.

[1] Presumably includes wild salmon, possibly from St. Pierre and Miquelon, but this is only speculation.

[2] Presumably includes wild salmon.

[3] Presumably includes wild salmon.

[4] United States import statistics for fresh salmon include shipments from countries that do **not** farm salmon, but which could tranship fresh product; Denmark, the FRG, the Netherlands, etc. fall into this category. There are other nations, however, which are also listed as shipping fresh salmon, but which have no logical reason for doing so. These nations include Taiwan, Mexico, Thailand, etc. These statistical errors are due to improper data entries, inaccurate captions on export declarations, shipping cartons, or invoices, or other reasons.

Table B2.--United States. Imports of fresh salmon, from major salmon producing countries, 1982-91.

Country	Fresh salmon imports									
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	US$1,000									
Canada	6,715	7,344	9,340	4,020	6,512	19,751	39,320	97,052	110,334	145,753
Chile	44	-	144	610	2,911	4,011	6,619	10,702	40,078	55,354
U.K.	1	33	813	3,003	2,899	4,812	3,617	8,241	6,788	7,899
Iceland	-	2	30	34	426	683	2,550	2,338	5,328	3,796
Norway	3,571	12,781	28,344	46,275	62,076	56,561	69,240	68,251	48,916	3,009
Faroes	-	-	-	-	-	-	-	2,433	310	2,467
Ireland	-	-	1	108	181	395	2,578	2,955	2,604	2,145
Australia	-	-	-	-	17	6	7	28	83	172
New Zealand	2	18	58	546	1,013	920	621	339	354	86
France[5]	9	17	9	275	92	19	-	-	10	18
Finland[6]	6	32	578	268	77	8	-	102	-	4
Japan	2	1	1	218	-	-	-	-	-	3
Sweden[7]	21	9	16	53	65	293	26	7	32	5
Sub-total	10,371	20,237	39,334	55,410	76,269	87,459	124,578	192,448	214,837	220,711
Other[8]	365	164	1,394	1,016	1,584	3,004	977	948	650	640
Total	10,736	20,401	40,728	56,426	77,853	90,463	125,555	193,396	215,487	221,351

Source: U.S. Bureau of the Census.

[5] Presumably includes some wild salmon, possibly from St. Pierre and Miquelon, but this is only speculation.

[6] Presumably includes some wild salmon.

[7] Presumably includes some wild salmon.

[8] *United States import statistics for fresh salmon include shipments from countries that do not farm salmon. These imports could include transhipments through countries such as Denmark, the Federal Republic of Germany, or The Netherlands. There are, however, imports of fresh salmon reported from very unlikely sources, including Oman, Thailand, and Morocco for 1991. These statistical errors are probably due to improper data entries, inaccurate captions on export declarations, shipping cartons, or invoices, or other reasons.*

Table B3.--United States. Harvests of farmed salmon, by quantity, 1980-1991.

Year	Atlantic	Pacific					Total
	Maine[9]	California[10]	Washington[11]			Total Pacific	
			Atlantic	Chinook	Coho		
	Metric Tons						
1980	0	N.A.	0	0	329	329	329
1981	0	N.A.	0	0	873	873	873
1982	0	N.A.	0	0	691	691	691
1983	0	N.A.	0	0	907	907	907
1984	23	N.A.	0	0	1,130	1,130	1,153
1985	68	N.A.	0	0	1,528	1,528	1,596
1986	136	N.A.	8	0	1,149	1,157	1,293
1987	800	N.A.	113	0	1,525	1,638	2,438
1988	1,700	N.A.	897	0	1,612	2,509	4,209
1989	1,539	N.A.	1,010	393	612	2,015	3,554
1990	2,082	454	650	501	205	1,810	3,892
1991	4,704	227	1,980	210[12]	N.A.[13]	2,417	7,121

Source: D.L. Sutherland, Fishery Statistics Division, National Marine Fisheries Service, NOAA, U.S. Department of Commerce for 1983-1989 (Washington State) and 1989 to 1991 (all regions). Production figures for coho salmon in Washington State for 1980-82 were obtained from *Aquaculture and Capture Fisheries: Impacts in U.S. Seafood Markets*, National Marine Fisheries Service, NOAA, U.S. Department of Commerce, Washington, D.C., April 1988, p.14.

[9] Includes only Atlantic salmon. Steelhead trout (recently reclassified as salmon) is also grown in Maine, but havests of steelhead are not included in these tables.

[10] California harvests include Atlantic salmon, coho salmon, and steelhead trout (now reclassified as a salmon species). No breakdown by species is presently available.

[11] Washington State salmon farmers also grow steelhead trout, but production statistics for this species are not included in this report.

[12] The Washington State harvest of chinook salmon includes the harvest of coho salmon for 1991. No statistical breakdown by species is available for 1991.

[13] Included in the havest of chinook salmon.

Table B4.--United States. Harvests of farmed salmon, by value, 1980-1991.

Year	Atlantic	Pacific					Total
	Maine[14]	California[15]	Washington[16]			Total Pacific	
			Atlantic	Chinook	Coho		
	US$1.00						
1980	0	N.A.	0	0	N.A.	0	0
1981	0	N.A.	0	0	N.A.	0	0
1982	0	N.A.	0	0	N.A.	0	0
1983	0	N.A.	0	0	3,000,000	3,000,000	3,000,000
1984	N.A.	N.A.	0	0	7,222,688	7,222,688	7,222,688
1985	N.A.	N.A.	0	0	4,581,840	4,581,840	4,581,840
1986	N.A.	N.A.	67,413	0	3,738,323	3,805,736	3,805,736
1987	N.A.	N.A.	1,175,984	0	5,001,141	6,177,125	6,177,125
1988	N.A.	N.A.	9,614,812	0	5,689,943	15,304,755	15,304,755
1989	10,180,500	0	8,356,287	1,611,701	1,962,232	11,930,220	22,110,720
1990	16,064,332	2,000,000	4,541,686	1,875,234	916,354	9,333,274	25,397,606
1991	29,970,392	1,000,000	N.A.	N.A.	N.A	1,000,000	30,970,392

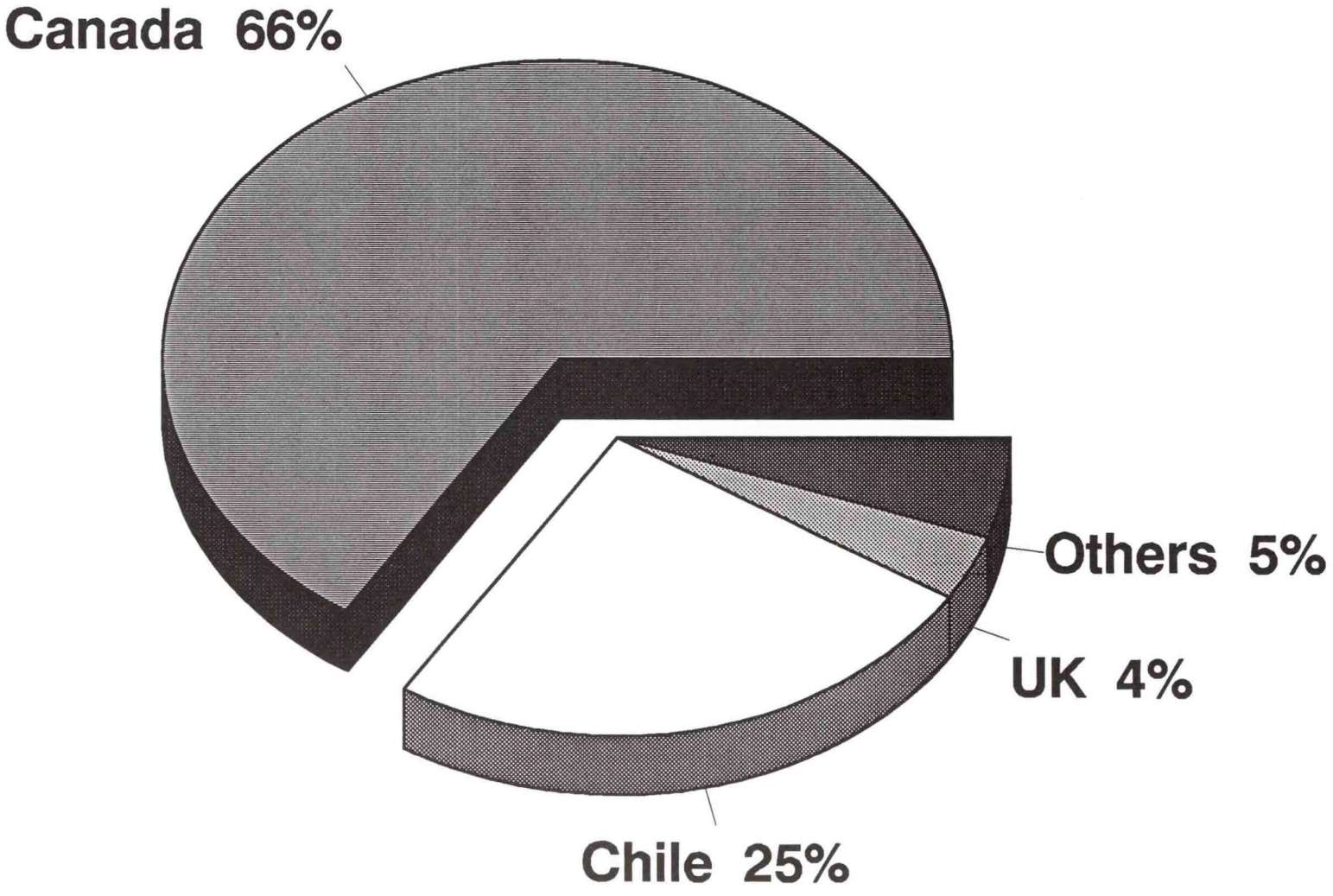
Source: D.L. Sutherland, Fishery Statistics Division, National Marine Fisheries Service, NOAA, U.S. Department of Commerce for 1989 to 1991.

[14] Includes only Atlantic salmon. Steelhead trout (recently reclassified as salmon) is also grown in Maine, but havests of steelhead are not included in these tables.

[15] California harvests include Atlantic salmon, coho salmon, and steelhead trout (now reclassified as a salmon species). No breakdown by species is presently available.

[16] Washington State salmon farmers also grow steelhead trout, but production statistics for this species are not included in this report.

UNITED STATES.--Imports of fresh salmon, by country and quantity, 1991.



UNITED STATES.--Imports of fresh salmon, by country and value, 1991.