Japan's "Fugu" or Puffer Fish Market

Japan imported nearly 1,700 metric tons (t) of fugu (commonly known as blowfish, globefish, puffer, or swellfish), valued at $9.7 million in 1987. Japanese imports of fugu have increased more than 140 percent since 1985.

The fugu (puffer) gets its name from its ability to expand its body by two to three times normal size when it becomes agitated or frightened, thus taking on a balloon shape. It does this by gulping air or water into a sac in its belly. This behavior serves to frighten away predators or intimidate rivals.

Background

Although fugu is one of the world's most poisonous fish, the Japanese have consumed it for centuries. The fugu's skin, ovaries, intestines, and liver contain tetrodotoxin, a powerful neurotoxin. If even a trace of these organs is left on the flesh of the fish, the consumer can die within minutes. A lethal dose of tetrodotoxin is about 1 mg and there is no known antidote. In Japan, about 60 percent of all fugu poisonings are fatal.

From 1974 to 1984, Japan had about 20 fugu poisoning fatalities per year. The trick to surviving a fugu meal is to make sure that it is prepared correctly—all traces of the internal organs must be removed from the fish's flesh. (To be completely fair to the fugu, it should be noted that fugu do vary widely in toxicity and some species are nontoxic.) The taste of fugu is said to be similar to chicken.

Domestic harvest

There are more than 100 species of fugu worldwide and nearly 25 percent of these are caught in the Sea of Japan, Yellow Sea, and East China Sea (Table 1). Two of the most important species harvested by Japanese fishermen are torafugu, *Fugu rubripes rubripes*, and karasu, *Fugu rubripes chinensis*.

Japanese domestic landings of torafugu and karasu range from 2,000 to 2,500 t a year. Both species are caught by longliners from September through March in the southwestern Sea of Japan and from July through January in the Seto Inland Sea. In November 1986, the Japan Tsushima Swellfish Longline Fishery Company of Tsushima, Nagasaki Prefecture, signed a 3-year private agreement with the North Korean Government to fish for fugu in the Yellow Sea off the west coast of North Korea. Because the North Koreans do not allow fugu longlining, the Japanese use only pole-and-line fishing methods. Japan has historically fished for fugu in North Korean waters because of the large size and high quality of the fish caught there. Fugu caught in waters off South Korea are said to be of lower quality.

From 300 to 800 t of pen-raised fugu are harvested annually from October through December in Yamaguchi Prefecture. Most of these are

Table 1.—Species of fugu (puffer fish) imported by Japan.

Japanese name and scientific name
Ishigakifugu, *Chilomycterus affinis* Gunther
Harisenbon, *Diodon holacanthus* Linne
Nezumifugu, *Diodon hystrix* Linnaeus
Hitozura-Harisenbon, *Diodon liturosus* Shaw
Akamefugu, *Fugu chrysops*
Sansaifugu, *Fugu flavidus*
Kusafugu, *Fugu niphobles*
Mefugu, *Fugu ocellatus*
Higanfugu, *Fugu pardale*
Komonfugu, *Fugu poecilonotum*
Karasu, *Fugu rubripes chinensis*
Torafugu, *Fugu rubripes rubripes*
Gomafugu, *Fugu strictonotum*
Mafugu, *Fugu vermiculare porphyreum*
Shosaifugu, *Fugu vermiculare vermiculare*
Shimafugu, *Fugu xanthopterum*
Kurosabafugu, *Lagocephalus gloveri*
Kanafugu, *Lagocephalus laevigatus inermis*
Sabafugu, *Lagocephalus lunaris lunaris*
Shirosabafugu, *Lagocephalus wheeleri*
Yoritofugu, *Liosaccus cutaneus* Gunther
Hakofugu, *Ostracioncubicus linnaeus*
Nashifugu, *Takifugu radiatus*

Table 2.—Japanese imports of fugu (fresh, chilled, and frozen), by country and quantity, 1980-87.

Country	Imports (t) 1980	1981	1982	1983	1984	1985	1986	1987
Taiwan		24	15				50	755
South Korea	798	518	332	302	381	513	806	682
China	25	114	154	186	209	149	148	199
North Korea	27	14	32	15	37	31	36	22
Total	850	670	533	503	627	693	1,040	1,658

Table 3.—Japanese imports of fresh, chilled, and frozen fugu, by country and value, 1980-87.

Country	Imports (US$1,000) 1980	1981	1982	1983	1984	1985	1986	1987
South Korea	5,825	4,203	2,365	2,426	3,220	2,797	6,530	7,997
China	75	666	1,081	1,203	1,382	1,178	1,190	921
Taiwan		59	15				43	661
North Korea	113	49	98	35	137	96	191	219
Total	6,013	4,978	3,559	3,664	4,739	4,071	7,954	9,797

Table 4.—Japanese imports of fresh torafugu, *Fugu rubripes rubripes*, by country, quantity, and average value per kilogram, 1980-86. All values on this table are C.I.F. yen/kg.

Year	Total Imports (t)	Average Value (¥/kg)	South Korea Amt. (t)	South Korea Value (¥/kg)	North Korea Amt. (t)	North Korea Value (¥/kg)	China Amt. (t)	China Value (¥/kg)
1980	204	2,648	204	2,648				
1981	193	2,773	188	2,778			5	2,599
1982	108	2,795	87	2,856			21	2,548
1983	77	3,112	77	3,112				
1984	121	3,499	118	3,565	4	1,313		
1985	138	2,842	126	2,919	6	4,861	6	2,208
1986	346	2,431	334	2,469	6	1,298	6	1,470

Table 5.—Monthly changes in Japan's import quantity and average value of fresh torafugu, *Fugu rubripes rubripes*, by country, 1985-86, and January-August 1987. All values are C.I.F. ¥/kg.

Year/ Month	Total Amt. (t)	Avg. value (¥/kg)	Quantity (t) S. Korea	N. Korea	China
1985					
Jan.	24	3,187	24		
Feb.	5	2,622	5		
March	4	2,288	4		
April		2,312			
May	1	2,180	1		
June					
July					
Aug.	1	1,426	1		
Sept.	2	1,723	1		
Oct.	14	1,957	9		5
Nov.	33	2,179	28	3	2
Dec.	54	3,499	51	3	
1986					
Jan.	31	2,302	31		
Feb.	54	1,022	54		
March	46	948	46		
April	2	1,878	2		
May	1	1,231	1		
June	2	1,332	2		
July	1	1,576	1		
Aug.	1	1,905	1		
Sept.	9	1,863	9		
Oct.	55	2,515	53	1	1
Nov.	81	2,832	71	5	4
Dec.	65	4,315	64	1	
1987					
Jan.	75	3,046	75		
Feb.	53	2,191	53		
March	17	2,691	17		
April	1	1,566	1		
May	7	1,550	7		
June	4	1,513	4		
July	3	2,027	3		
Aug.	7	2,057	7		

Table 6.—Japanese imports of frozen fugu, by country, quantity, and average value per kilogram, 1980-86. All values are C.I.F. ¥/kg.

Year	Total imports (t)	Avg. value (¥/kg)	S. Korea Amt. (t)	S. Korea Value (¥/kg)	N. Korea Amt. (t)	N. Korea Value (¥/kg)	China Amt. (t)	China Value (¥/kg)	Taiwan Amt. (t)	Taiwan Value (¥/kg)
1980	646	1,291	594	1,331	27	978	24	687		
1981	477	1,158	330	1,188	14	748	109	1,252	24	561
1982	426	1,381	246	1,399	32	762	133	1,625	15	254
1983	426	1,466	225	1,484	15	547	186	1,519		
1984	506	1,385	263	1,283	34	818	209	1,606		
1985	555	936	387	702	25	386	143	1,664		
1986	694	733	472	597	30	757	142	1,388	50	148

Table 7.—Monthly changes in Japan's import quantity and average value of frozen fugu, by country, 1985-86, and January-August 1987. All values are C.I.F. ¥/kg.

Year/ Month	Total Quantity	Average Value	Quantity (t) South Korea	North Korea	China	Taiwan
1985						
Jan.	25	1,146	11		14	
Feb.	94	740	89		5	
March	84	600	79		5	
April	90	513	90	1		
May	30	584	25		5	
June	12	401	12			
July	26	2,335	26			
Aug.						
Sept.	9	1,018	9			
Oct.	30	1,307	13		17	
Nov.	23	487	5	18		
Dec.	132	1,385	29	6	96	
1986						
Jan.	104	1,051	72		32	
Feb.	127	655	120		7	
March	99	443	85	1		14
April	94	457	76	8	10	
May	45	410	27			
June	40	362	19	1	2	18
July	7	501	3	3	1	
Aug.	30	918	6	7	17	
Sept.	5	1,080	1	3	2	
Oct.	24	801	21		21	
Nov.	27	885	23		4	
Dec.	92	1,275	19	8	64	
1987						
Jan.	143	715	5		58	80
Feb.	44	431	19		25	
March	45	442	25			20
April	22	346	11			10
May	16	659	16			
June	250	400	86		2	162
July	107	312	19			89
Aug.	31	179	7			23

sold fresh or live at auction in Karatsu (Yamaguchi Prefecture), and shipped to major cities, such as Osaka and Tokyo.

Imports and Markets

Japan allows 22 fugu species to be imported (Table 1). Annual fugu imports averaged about 650 t from 1980 to 1985, valued at $4.5 million (Tables 2, 3). The figu's increasing popularity in recent years among younger Japanese consumers pushed imports to a 1987 record high of 1,700 t, valued at nearly $9.8 million. Taiwan was the major exporting country by quantity in 1987, shipping over 750 t, 15 times the quantity exported in 1986. South Korea was a close second with exports of 680 t, but was the hands-down winner by value—nearly $8 million. China and North Korea also exported fugu to Japan in 1987. Fresh torafugu is the major species imported from South Korea, China, and North Korea (Tables 4, 5). Frozen sabafugu, *Lagocephalus lunaris lunaris*, and kusafugu, *Fugu niphobles*, are also imported from these countries, as well as Taiwan (Tables 6, 7).

Fresh (or live) and frozen fugu are marketed differently in Japan. Both torafugu and karasu are normally marketed fresh or live at weights of 1.5-2.0 kg per fish. These two species are highly valued, selling for 3,090-4,700 ¥/kg (about $23-$35/kg at ¥133/US$1) at Tokyo's Tsukiji Fish Market (Table 8). They are usually served as sashimi (very thin slices of raw fish) at expensive restaurants. Often fugu sashimi will be arranged in patterns resembling flowers or birds.

Frozen sabafugu and kusafugu are utilized primarily for processing and stewing, although some may be consumed as sashimi. They are usually imported frozen in 10 kg blocks and sold directly to the processors, bypassing Japan's wholesale auction markets. Two typical fugu processed products are fugu "ichiyaboshi" (semidried whole fish) and dried fugu or "fugu rolls" (headed fugu butterfly fillets pressed between rollers and dried).

Because the fugu's skin and viscera are extremely toxic, 14 prefectures, including Tokyo, allow only certified chefs to prepare fugu. All fugu cooks must take intensive courses, apprentice at least 2 years, and pass written exams. There are some 30 steps prescribed by law for preparing fugu.

Table 8.—Live and fresh fugu sales at Tsukiji Market, Tokyo, Japan; by quantity and average price per kilogram in yen, 1980-86.

Year	Quant. (t)	Yen per kilogram
1980	484	3,299
1981	553	3,364
1982	452	3,528
1983	556	3,748
1984	644	3,513
1985	709	4,024
1986	895	4,694

Import Regulations

Because of the obvious health risks involved with the consumption of fugu, the Japanese Ministry of Health and Welfare rigidly controls imports of fugu into Japan. Fugu may be imported either unprocessed or gutted (as long as the identification of each fish is not impaired). Fish must be tagged with an official certificate from the exporting country identifying it by scientific name, fishing ground, and attesting to the fact that it received proper sanitary handling. If the fish is frozen, it must have been deep frozen and stored at a temperature below −10°C. In addition, each fish should be individually frozen for easy identification. If this is not possible, fish may be frozen in blocks, but each fish's back and belly must be visible for species identification. If official certificates are incomplete or detached, or if the cargo is mixed with other species restricted from import, the cargo may be returned to the exporter. Imports of the same or other fugu species harvested in other waters must be negotiated with the Japanese Government to determine certificates of toxicity, fishing ground, species, etc. Import duties are 10 percent of the C.I.F. value for fresh, frozen or fillet.

U.S. Puffers

A number of puffers are caught in North American waters. One of the most common is the northern puffer, *Sphoeroides maculatus*, a nontoxic species which was popularly marketed as "sea squab" along the Atlantic Coast during World War II. Unfortunately, the northern puffer is not on Japan's current import list and consequently cannot be imported into Japan. Ministry of Health and Welfare officials have indicated that negotiations for market access might be possible. Although the Japanese are not familiar with northern puffer, it could find a market if it is of sufficiently high quality. (Source: IFR-88/80.)

Soviet Fish Catch off Latin America

The Soviet distant-water fleet caught a record 1.0 million metric tons (t) of fish off Latin America during 1987, surpassing the previous record (0.8 million t, set in 1986) by over 20 percent. Latin American grounds are some of the few grounds in which the Soviets have reported significant catch increases in recent years.

Almost 10 percent of the total Soviet fisheries catch was taken off Latin America in 1987. Much of the 1987 increase was a result of higher catches in the eastern Pacific outside the 200-mile zones of Peru and Chile, where about 85 percent of the 1987 catch (over 0.8 million t) was taken. Most of this catch was Chilean jack mackerel. The remainder of the Soviet catch off Latin America, totalling nearly 0.2 million t, was taken in the Southwest Atlantic, mostly in Argentine waters.

Reflecting the growing importance of Latin American grounds, the Soviet Union seeks access to fishing grounds off several Latin American countries. The Soviets are particularly interested in access to Argentine and Peruvian grounds. The Soviet Union began operating in Argentine waters during May 1987, under the auspices of a bilateral fishing agreement that allows the Soviets to catch almost 0.2 million t of fish annually. Most of the Soviet catch in the southwest Atlantic was squid, southern blue whiting, and grenadier. The Argentine-Soviet agreement was renewed in October 1988. Soviet efforts to sign agreements with Peru and Uruquay have been stymied by strident local political opposition and demands by the Latin Americans for a large share of the Soviet catch. Nevertheless, Peru reportedly signed a bilateral agreement with the Soviets in early December 1988.

Canada's Atlantic Aquaculture Industry

Atlantic salmon was Canada's most valuable species of farmed fish, with production worth C$14 million in 1987, close to the value of Atlantic Canada's herring or haddock fisheries. Mussel farming was worth C$3 million and it continues to grow despite an incident involving toxin in late 1987. Production of cultivated trout, European oysters, bay scallops, sea scallops, and other species is expanding and shows promise for significant expansion in the future. By 1995, Canadian fish farmers might be able to produce 45,000 t of fish and shellfish worth over $225 million.

Role of Government

The Canadian Government's Department of Fisheries and Oceans (DFO) plays an active role in Atlantic Canada's aquaculture industry. A key responsibility includes enacting and enforcing regulations. The expanding use of sheltered bays and inlets for fish farming created a need for regulations to avoid conflicts with commercial fishermen, navigators, recreational boaters, and others. The DFO is particularly concerned that marine farming and traditional fisheries coexist, and it works with other Federal ministries, provincial governments, and local municipalities to support and manage the orderly development of aquaculture.

Despite impressive growth in recent years, aquaculture is still a new industry which is rapidly developing. The need for scientific research remains critical. The intricate process of growing wild creatures in captivity requires constant effort to improve growing techniques and broodstock, control diseases, improve nutrition, and to deal with unforeseen problems—anything from a mysterious poisoning to the unexpected effects of a very cold winter. The DFO is assisting the industry by sponsoring research in all of these areas.

One of DFO's main aquaculture activities is preserving the health of fish stocks. The DFO Fish Health Unit, located at the Halifax Laboratory, enforces Federal Health Protection Regulations for both the Scotia-Fundy and Gulf Regions. Its job is to test fish for disease. All salmon, for example, going from hatcheries to cages have to be tested for enteric redmouth disease, furunculosis, and bacterial kidney disease (BRD), the latter being a particular concern because it's believed to be transferrable through the egg. Fish crossing international boundaries, provincial boundaries, or even being transferred from one water system to another must be tested. The regulations are stringent because most outbreaks of fish disease occur when fish are transferred from one site to another without proper controls.

The Fish Health Unit certifies both hatcheries and fish farms. Private groups and individual growers are building an increasing number of hatcheries in the Scotia-Fundy region, adding to the half dozen Federal salmon hatcheries which stock rivers and supply marine farmers with salmon smolts. The Unit investigates fish kills, checks for chemical and other environmental hazards, and monitors the approach of paralytic shellfish poisoning. This practical program is complemented by a group conducting research into fish disease such as furunculosis and BKD. At the Halifax Laboratory a team of scientists is exploring the different strains of these diseases and how and why they kill fish—essential information before they can be controlled or eradicated.

Aquaculture Programs

The center of Atlantic Canada's salmon culture industry is the Scotia-Fundy region. Conditions there are ideal for salmon farming; the flushing action of the tides, the upwelling of nutrients, suitable water temperatures, and protected sites have helped this region to become one of the best salmon growing areas in the world. Canadian production of farmed Atlantic salmon, *Salmo salar*, totaled 2,800 t in 1987, and officials believe farmed salmon production will reach 27,000 t by 1990, making Canada the third largest producer of farmed salmon in the world.

Responding to the need for information on aquaculture by new entrants to the industry, the DFO opened the Salmonid Demonstration and Development Farm (SDDF) at Lime Kiln Bay in 1986. The SDDF provides commercial fish farmers with scientific and technical information about culturing salmon in cages and demonstrates how a salmon farm works. It also conducts research and develops improved grow-

Mexico Gets New Fisheries Minister

Mexican President Carlos Salinas de Gortari announced his new cabinet on 30 November 1988. His new Fisheries Minister is María de los Angeles Moreno Uriegas. Moreno was an Under Secretary under Salinas at the Secretariat of Programming and Budget and directed the President-elect's Committee on Fisheries Planning. She has also served on the Board of Directors of the government-owned fisheries export marketing company. She is reputed to be an expert on the international trade in seafood products.

ing techniques. The farm receives financial contributions under terms of a Canada-New Brunswick Economic Resource Development Agreement. It is managed through the St. Andrews Biological Station, but is run as a working farm by a private company under contract. Scientists with expertise in salmon biology and culture, genetics, fish disease, nutrition, and marine engineering direct the SDDF's work along with an advisory committee composed of federal, provincial, and private sector representatives who ensure that the research is relevant to the needs of the industry.

The main emphasis of the SDDF research is nutrition. Various diets are tested, especially moist vs. dry formulations. Combinations of different feed mixtures at various stages of the salmon's complex growth are also examined. Testing includes different vitamin and mineral supplements. Presently, the nutritional analysis is done at the Halifax Laboratory of the DFO, but a nutrition laboratory is scheduled to open soon. Learning the physiology and biology of fish (how they work and how they grow) is another priority. In some experiments smolts have been manipulated to see if periods in salt water affect their "growout." One potentially useful discovery is that artificially extending daylight hours (especially between August and November) makes salmon grow faster. Other programs are designed to improve management techniques, evaluate sea cage systems, and to upgrade stock.

Associated with the SDDF is the Salmon Genetics Research Program (SGRP) jointly sponsored by the DFO and the Atlantic Salmon Federation, a private nonprofit conservation group. Scientists are trying to develop fish with improved disease resistance. They are also working to delay sexual maturation so that the fish keep growing instead of diverting energy for breeding.

Genetic research for characteristics suitable for better domesticated stock is only part of the SGRP's program. Scientists at the Atlantic Salmon Federation's research facilities near St. Andrews, are also working on "sea-ranching," releasing smolts into the ocean in the expectation that they'll return to their place of birth as mature adults where they can be harvested. Unfortunately, less than 3 percent of these smolts return as mature adults (in Iceland, 20 percent return to spawn in their native rivers). In some rivers, however, there's a higher and earlier return rate suggesting that the salmon don't migrate as far in the ocean; it is possible that these fish might form the stock for sea ranching.

At the DFO Biological Station in St. Andrews, scientists are conducting an interesting experiment in which they are hoping to extend the "time window" when smolts can be released into salt water. This is normally only a couple of weeks in spring when the physiology of the year-and-a-half old salmon changes—their dark stripes become silver and they prepare to swim downstream. However, they die if they reach salt water too early or too late. A million smolts go into the ocean at that time, and it's a hectic period which taxes both hatchery and laboratory facilities since all the batches have to be tested for disease and transported within a very limited time frame.

Meanwhile, commercial salmon sea cage operations are being monitored by DFO scientists for possible pollution problems, especially from aquaculture facilities themselves (uneaten feed, chemicals, and fish waste). Most of the salmon growers in Atlantic Canada are concentrated in L'Etang estuary near St. George, where most of the 34 New Brunswick sites are located (there are six more in Nova Scotia). L'Etang is ideal because it combines shelter from the open sea with warmer winter temperatures—a rare combination on the Atlantic

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Argentine Fisheries Developments Noted

Argentine fishermen caught 550,000 metric tons (t) of fish in 1987, an increase of 30 percent over the 411,000 t caught in 1986. Argentina exported 241,200 t of fishery products during 1987, valued at a record US$267 million. Most of the Argentine shipments were hake and squid. The primary reason for the expanded shipments was increased demand for demersal finfish in the European Community (EC) and the United States, and increased purchases by Australia and communist countries. Substantially higher squid catches, accompanied by strong demand for squid in the EC was also an important factor.

The Argentine fishing industry is highly dependent on export markets despite efforts to increase domestic consumption. The Argentine Government has bilateral agreements with the Soviet Union and Bulgaria, which permitted a limited number of fishing vessels from those countries to operate in Argentine waters during 1987. The Government has been unsuccessful in its efforts to negotiate similar agreements with Spain, Japan, and other countries.

The U.S. Embassy in Buenos Aires has prepared a 24-page report summarizing recent fishery developments in Argentina. The report has information on catch, exports, bilateral fishery relations, foreign investment, and government involvement in and policy toward the fishing sector. The report also includes detailed statistical appendices on catch and exports. U.S. companies can obtain a copy of "1987 Report on the Argentine Fishing Industry" for $13.95 and a $3.00 handling fee (total $16.95, personal checks or money orders only) by ordering report PB89-127880/GBA from NTIS, 5285 Port Royal Road, Springfield, Virginia 22161. (Source: IFR-88/109N.)

Coast. But scientists are concerned that wastes from the cage operations will create algal blooms that might adversely affect salmon growth or other marine life, especially if aquaculture facilities in the L'Etang estuary continue to expand and the area becomes more congested. Tests show that this is not happening yet, but nutrient and oxygen levels in the water are being carefully monitored.

Trout farming is the oldest aquaculture sector in Atlantic Canada. Total trout production in 1986 was about 2,400 t worth C$16 million. Rainbow trout, *Oncorhynchus mykiss*, and brook trout, *Salvelinus fontinalis* are both raised commercially, frequently in conjunction with salmon farming: About a third of salmon farmers also raise trout. There are a few large operations growing only trout, the largest being in Bras D'Or Lake in Cape Breton. But hundreds of freshwater operations have sprouted throughout the Maritimes, many for angling purposes. Trout reach "pan size" easily, but bringing them up to large sizes takes more sophisticated knowledge. Nutritional analysis and feed development have been done for trout as for salmon, and the same disease precautions are taken. Atlantic Canada's largest trout farm was opened in Prince Edward Island (PEI) in the summer of 1988. The farm, a joint venture between Norwegian and Canadian investors, plans to market about 400 t of rainbow trout annually (about 200,000 fish).

The most widely cultured shellfish species in the Scotia-Fundy Region is the blue mussel, *Mytilus edulis*, grown by about 100 marine farmers along the coast in sheltered bays. In 1987, the Canadian production of blue mussel was valued at C$1.5 million. About half of these blue mussels were raised around Prince Edward Island. This industry has expanded at a hectic pace. The mussels grow quickly in the cold northern waters which are their natural habitat, and seed is easily collected in the wild, as opposed to other cultured mollusks which require hatcheries. When cultivated mussels were first introduced to the market they were sold for the same price as wild mussels. When consumers realized that farmed mussels have more meat than their wild counterparts, the price for cultivated mussels doubled.

Provincial and Federal governments have helped with financing, technology, and other practical matters. Since mussels require only an artificial structure to grow, little research into genetics or nutrition is needed. The sudden and unforeseen toxic poisoning that hit Prince Edward Island mussels in late 1987, resulted in one of the most intense scientific efforts Canada has ever seen to identify the toxin (domic acid) causing the problem. The effort by Federal and provincial authorities underscores the importance of research in marine farming, especially of shellfish, for health protection. Blue mussel production in the late 1970's was about 10 t, but by 1986, Nova Scotians produced 1,400 tons.

High quality mussels are produced using mainly the longline systems of suspended culture. The mussel industry is composed of two general types of operation: Those producing significant commercial quantities of mussels and those growing less than 15 t annually. Collection of seed mussels for sale to growers is a new activity that is growing quickly. The mussel farming industry faces several constraints in the future which will require research and monitoring. These constraints include the capacity of estuaries to support mussel culture, the impact of mussels on the ecology of the estuary, the spread of paralytic and diarrehetic shellfish toxins, and the quality of the waters.

American oysters, *Crassostrea gigas*, are being grown successfully at sites along the coast of Nova Scotia. In 1986, harvests of oysters exceeded 3,000 t in Atlantic Canada. Canadian oyster farmers also harvested a small quantity of European oyster, *Ostrea edulis*. The European oysters were introduced in the late 1960's by DFO personnel, who nurtured them to the commercial stage. They grow well and the market is good, but expansion has been slow because of the shortage of hatchery capacity, a problem that should be gradually overcome as new private hatcheries add to the government and university facilities that served the industry in its infancy.

Early experiments with the native oyster in the Bras D'Or lake were biological successes, but were not commercial successes. Native oyster culture operations are concentrated in the Gulf Region. Because oysters hibernate in the winter, they can be harvested in the late fall and put in cold storage to force hibernation and kept for up to 3 months. Exporters can then take advantage of the high prices available in the European market during the winter holidays.

Some aquaculturists believe that the bay scallop will be Canada's next success story. The bay scallop, a small scallop introduced from the U.S. Atlantic coast, has been grown experimentally at selected sites in Nova Scotia with good results. One of its advantages is that it grows to maturity in a year. It's main disadvantage is that it does not tolerate harsh winter conditions. Bay scallops provide a far smaller meat than the sea scallop, but it is prized by the Japanese. Meanwhile, the Halifax Laboratory, which is equipped with a quarantine unit (all live fish coming into the country must be quarantined), is hoping to bring in new stock to expand the genetic base of both the bay scallop and the European oyster. Atlantic farming of bay scallops began with only a small number of individuals and would likely benefit from expanded broodstock and improved genetic diversity.

Sea scallops are also being evaluated for aquaculture. Scientists at St. Andrews are testing various kinds of suspension cages at Lime Kiln Bay

Table 1.—Aquaculture production in Atlantic Canada, by quantity, 1984-86.

Species	Production (t) 1984	1985	1986
Atlantic salmon	222	349	655
Blue mussel	876	909	1,845
Rainbow, brook trout	NA[1]	NA	947
American oyster	NA	NA	2,400[2]
European oyster	NA	NA	5

[1]Not available.
[2]Includes both wild and cultured species.

near the SDDF, and are trying to learn if there's enough spatfall in Passamoquoddy Bay and the Bay of Fundy that could be gathered in the wild to support a scallop aquaculture industry. If not, development of this industry would be dependent upon hatchery production.

Lobstering is big business in Canada. In 1987, Canadian fishermen caught 35,400 t of lobster valued at C$264 million. Any program that can enhance natural stocks or raise lobsters in captivity is of significant interest to Atlantic Canada. A long-term pilot project at the St. Andrews Biological Station has shown that lobster can be grown and reproduced in captivity. The economics are difficult and attempts to grow them commercially have not yet been successful. Nevertheless, this research has had positive results. For example, researchers discovered that lobsters kept at cold temperatures will not molt or spawn, are resistant to disease, maintain their meat quality for a long period, and don't need feeding. This has provided the scientific basis for land-based lobster pounds which allow Canada to supply high quality lobster to international markets throughout the year. There is also continuing work underway by private lobster companies in cooperation with DFO to grow "canner" lobsters to market size.

A small number of halibut are being grown at the St. Andrews Biological Station and in a sardine weir on New Brunswick's Fundy Coast. Preliminary testing has shown halibut take well to confinement. They're considered a good candidate for aquaculture because of their high value and because, like salmon, the whole fish is purchased by the consumer, not just a filet. Larval studies are underway to see if species like striped bass, haddock, halibut, eels, and other marine fishes can be reproduced from the egg in captivity. This work is more basic than applied research and may not prove relevant to marine farming for some time.

Conclusion

Aquaculture in Atlantic Canada is a rapidly growing industry, with production growing steadily in recent years. The immense interest in aquaculture has lead the DFO and provincial governments to develop joint programs and legislation ensuring the safe and orderly development of the industry. Atlantic Canada has benefitted greatly from aquaculture through increased employment and exports and these benefits should continue to increase as the industry expands. By 1990, At lantic Canada might be the world's third largest producer of farmed fish and shellfish if production goals are achieved.
(Source: IFR-88/94.)

Chilean Fisheries Growing Rapidly

The Chilean fishing industry has been the fastest growing sector in the Chilean economy during the past 11 years, growing at an average annual rate of 10 percent. In 1987, however, the industry experienced its first decline in recent years. Fishery landings totaled 4.9 million metric tons (t) in 1987, a 13 percent decline from 1986 levels. Fishermen reported record jack mackerel landings in 1987, which were 50 percent higher than 1986 landings. The overall decline in landings was caused by a sharp decline in anchovy landings, which plummeted from 1.5 million t in 1986 to only 0.3 million t in 1987. Almost 90 percent of all 1987 landings were reduced into fishmeal and fish oil.

Despite the declining catches, however, export earnings actually increased in 1987. Fisheries accounted for 13 percent of Chilean exports in 1987, earning $638 million (up 23 percent from 1986). The increase in export earnings was mainly due to a rise in the world price of fishmeal during 1987. The Undersecretariat of Fisheries tightened pelagic and shellfish management measures because of concern about overfishing (especially of sardine and anchovy stocks) and worked on developing a new fisheries law. Announced investments in the fishing industry totaled about $100 million, with over 40 percent going to the growing salmon culture and processing industry.

The U.S. Embassy in Santiago has prepared a 41-page report summarizing recent fishery developments in Chile. The report has information on landings, fleet, development programs, new investment projects, ports, aquaculture, industry developments, markets, government policies, and research. The report includes a list of government institutions and private companies and detailed statistical appendices on landings, processing, and trade. U.S. companies can obtain a copy of "Chile: Industrial Outlook Report, Fishing Industry 1987" for $13.95 and a $3.00 handling fee (total $16.95, personal checks or money orders only) by ordering report PB89-122311/GBA from NTIS, 5285 Port Royal Rd., Springfield, Virginia 22161. (Source: IFR-88/106N.)