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Canada

SALMON AQUACULTURE

A Report on the Canadian Industry

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Food Products Directorate
Fishery Products Division
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Regional Industrial Expansion

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SALMON AQUACULTURE

I. GENERAL BACKGROUND

Aquaculture, in its broadest sense, is the cultivation of any marine or fresh water fish or plant. It accounts for approximately 12 per cent of the world's total aquatic harvest and includes such diverse fish as carp, milkfish, salmon and various shellfish and plants such as irish moss and porphyra.

Aquaculture may be carried out in the ocean or in land based tanks, ponds, or even ditches. Most species will be held in different types of facility during different stages of their life cycle. One variation, known as ocean ranching, does not use confinement at all but relies on the homing instinct of some species to bring them back to their point of release when mature.

Economic viability depends on a species which is either easy and inexpensive to grow or of high unit value. Most of the industry falls into that first category and comprises individual, family or small collective operations raising species such as carp or milkfish for personal consumption or local marketing. In China, the world's largest aquaculture producer, carp is often raised in irrigation ditches without the benefit of (or need for) scientific husbandry.

By contrast, contemporary aquaculture development is occurring with species chosen because of high price, strong demand, limited supply or because the cultured version is superior in quality or available over a longer season. This category has always included several varieties of shellfish. Among the finfish, plate-size trout were the first species to achieve commercial prominence but now other salmonids are being farmed successfully in many temperate zone countries.

As natural harvests of other species begin to fall short of demand, they too will be added to the list of candidates for aquaculture development. Experimental work is currently in progress to develop technology for raising cod and some flatfish species in captivity.

Aquaculture today is said to be in the same stage of development that animal husbandry was 400 years ago and the same types of problems must be solved. Wild species must be tamed or domesticated, a process that can take several generations. Then selective breeding must be practised and disease control methods, feeding requirements and all the other techniques of successful husbandry developed in order to build a commercially viable technology.

II. SALMONID AQUACULTURE BACKGROUND

Salmonid aquaculture is the fastest growing development in the field today. It began with the commercial raising of rainbow trout (Salmo gairdnerii). In Canada, this began with the establishment of government hatcheries which raised fingerlings for restocking lakes and rivers in order to support the recreational fishery. Some fry were sold to owners of lakes and ponds for the use of private fishing clubs and, eventually, to commercial farmers who raised trout for sale to the restaurant trade.

Several of these commercial trout farms are still in business selling primarily a fresh product to the hotel and restaurant trade and to specialty retail stores. Most of the development in rainbow trout aquaculture, however, has taken place in other countries - United States, north-west Europe and Japan - where a warmer climate and longer growing season make possible a more cost efficient operation. Most of the frozen rainbow trout on the Canadian retail market today is imported.

Serious commercial aquaculture of salmon began in north-western Europe with the raising of Atlantic salmon (Salmo salar) in Scandinavia and the British Isles. Norway is still the leading producer of farmed Atlantic salmon with Scotland, Ireland and Iceland also being important producers. Since the early 1980s, however, salmon aquaculture has spread to many other countries, often with Norwegian investment and technological support, and, in the Pacific rim countries the technology has also been applied to the culture of Pacific salmon (Oncorhynchus species).

On Canada's east coast commercial farms raise only Atlantic salmon although there is some work being done with Arctic char (Salvelinus alpinus) and some farmers have raised faster maturing trout during their first year or two in order to generate sales revenue while the first crop of salmon was growing to market size.

On the Pacific coast of Canada some Atlantic salmon is being introduced but most of the farms raise Coho (Oncorhynchus kisutch) and/or Chinook (O. tschawytscha) salmon. Sockeye salmon, which would also be commercially attractive, is not yet an aquaculture species because it is an algae feeder and a practical commercial feed acceptable to the fish has not yet been developed.

III. SALMON AQUACULTURE SYSTEMS

Culture techniques practised in Canada are essentially the same regardless of which salmon species is being raised. Eggs are obtained from a brood stock selected and maintained for that purpose. The eggs are hatched in a hatchery, usually in winter, and the tiny fish or parr are kept indoors in fresh water tanks until Spring. The fish are then moved to outdoor tanks where they are grown until they develop to the smolt stage (physiologically developed to live in salt water). The fish are then moved to salt water grow-out stations where they are raised to market size.

Most grow-out stations consist of net cages suspended from floating frames anchored close to shore but there is increasing interest in dry-land enclosures and there are large seaworthy cages being designed for use farther off-shore. Experimental work is also under way to develop fundamentally new fish grow-out systems that simulate more closely the conditions of the wild environment (but without the hazards). Finally, there are ranching systems, notably in Iceland, where smolt are released to the open sea relying on the salmon's homing instinct to bring it back to its point of release when mature.

Each of these culture systems has characteristics which make it the appropriate choice in particular circumstances.

Net Pens: These are the most popular, certainly in Canada. They may be square or circular and are usually about 10 to 15 metres square or in diameter. Depth will vary with site conditions and the size of the fish. The cages normally abut one another in rows with a walkway to facilitate inspection, servicing and feeding. Many installations, particularly larger ones, have automatic feed dispensers.

Although net pen sites are normally sheltered, the pens must be sturdy enough to withstand wave action and such storms as may be encountered. They must also be designed to protect the fish from natural predators. At some sites an overhead net to keep out flying birds is adequate but in most regions protection must be provided against animals such as seals and otters or diving birds such as cormorants which either breach the net under water or reach through it when the salmon crowd close to the inside of the mesh. Considering that market ready salmon can be worth $50 each, poaching is another hazard to be considered.

Aside from being sheltered, cage sites must have a strong enough current or tide to keep water circulating through them and to prevent a build up, on the bottom, of feces, unconsummed food and other organic debris. Lack of such conditions can lead to a violation of environmental pollution standards and to the spread of disease among the fish.

One of the most important site selection considerations is water temperature. Most vertebrate fish, including salmon, die almost instantly, when water temperatures drop below -0.7°C. This is not a problem along the British Columbia coast but, in Atlantic Canada, the number of suitable site areas where water temperatures never fall below this figure is limited. Note that wild fish can cope with this problem by moving to a safer area or depth when the water begins to get dangerously cold. High temperatures, while not lethal, do affect growth. Ideally, temperatures should be below 20°C.

In some areas, such as the Sunshine coast north of Vancouver, British Columbia, there is competition and, in some instances, animosity among groups competing for foreshore use. Light commercial and recreational users of the foreshore and shoreline property resent the perceived pollution and industrialization threat they associate with aquaculture development.

Site licenses are granted by the provinces generally on the basis of the applicant's qualifications, site suitability, and an overall development plan for the industry

but there are federal and municipal regulations covering the location and operation of fish farms which also must be complied with.

Deep Sea Cages: This is an extension of the net pen concept. It is not currently being used by any Canadian company. The premise is that a seaworthy cage can be moved into warmer water, such as in the Gulf Stream, and away from the pollution and community acceptability problems of the inshore sites. There are concerns about reliability, particularly in the light of bad weather problems encountered by some oil drilling platforms. The final choice, however, will be based on cost. The added capital investment required for such a system could be a problem when the rapid expansion now being experienced by the industry leads to market saturation and a drop in selling price.

Dry Land Systems: These systems, as the name suggests, use grow out tanks on shore. Such a system has been developed in Nova Scotia to grow selected strains of Chondrus crispus (Irish moss) used to extract carragheenin gum which is an ingredient of many food, beverage and pharmaceutical products.

A dry land system is used for salmon aquaculture in Scotland and others are under construction in other countries including Iceland. In Canada a land based salmon farm is being built on Vancouver Island and another has been operating since the autumn of 1986 at St. Omer in the Baie des Chaleurs district of Quebec.

The advantages of the dry land systems are improved control of disease, predators, feed consumption and water temperature. The investment is higher than for conventional net cage farms but there is not the risk of storm damage associated with deep sea cages so the potential for being competitive with net cage systems is better than the initial cost would suggest. A supply of clean salt water is, of course, essential.

Ranching: can be viable only where there is no commercial fishery apt to intercept the returning fish, a condition that occurs in very few places. Even if there is little or no such interception, the survival rate based on the number of smolts released is low.

New Aquaculture Systems: Research is being conducted, principally in Norway, into new aquaculture system concepts designed either to improve the operational efficiency or to improve the quality of the product. This is in response to complaints that farm raised fish lacks some of the texture, flavour, and even nutritional quality of wild caught fish. Some of this may be defensive public relations instigated by the capture fishery but there is precedent for such complaints in the history of the domestication of other species such as meat animals. Aquaculturists have made an effort to improve flesh colour of salmon (make it redder) through diet but, for the most part, feed formulations have been programmed for minimum cost, high growth rate and good feed conversion ratios. Recent accusations (unproven) that farmed salmon are lower than wild salmon in omega - 3 fatty acids have prompted increased attention to the relationship between diet and product nutritional quality.

The fundamental principle of cage rearing is also coming under scrutiny by those who suspect that the lack of exercise is giving cage reared fish less firm flesh texture. The position of the net cage as the primary means of confining salmon during grow-out is not going to change in the near future but eventually, as competition increases, one of these new systems will establish itself, at least in the premium end of the product mix.

IV. DISEASES

The most common diseases are bacterial kidney disease (BKD), furunculosis and vibriosis. Most diseases can be controlled by vaccination (by immersion) but BKD has such a long gestation period that it must be controlled by identifying and eliminating infected eggs.

Fish under stress because of such factors as over-crowding or unnatural environment are more susceptible to any disease so geneticists are trying to breed in greater stress tolerance as well as improved growth, yield, and quality factors, and system designers are trying to simulate the natural environment more closely.

Control of BKD has been designated by the British Columbia Salmon Farmers Association as the first research priority facing the industry.

V. HATCHERY PROGRAMS

The long term success of any aquaculture program depends on an adequate supply of suitable eggs. Quantity is not a problem but quality is critical.

Eggs must be disease free and Canada has a very strict protocol for the handling, transfer and inspection of eggs to prevent the spread of disease, particularly BKD, which must be detected at the egg stage.

Eggs must be healthy in the sense that they will give a high yield of strong fish.

Eggs must be genetically strong. There is some disagreement as to how this condition can be maintained but there is no question as to the need for a good gene pool that will preserve the desirable characteristics of a strain and avoid the inadvertent introduction of undesirable traits. There is also concern over the genetic consequences of escaped farm fish mating with and upsetting the genetic strength of wild salmon.

Canadian government policy is for the private sector to operate its own brood stock-hatchery program. Canadian government practice has been to supply the private sector with eggs from stocks that are surplus to the government's own programs. The transition from government to private supply is taking place but has been slowed down by the increased demand during the past few years and by farmers' complaints of poor quality from some of the newer commercial suppliers.

VI. SALMON AQUACULTURE IN ATLANTIC CANADA

Because of the location of the Gulf Stream, the temperature of Atlantic Canada's coastal waters is generally lower than that enjoyed by the British Isles and Scandinavia. Therefore the number of sites where temperatures above -0.7°C (the lethal temperature for salmon) can be relied on is limited. Consequently commercial development of salmon aquaculture has been limited to an area near the entrance to the Bay of Fundy which includes Passamaquoddy Bay and Grand Manan Island. Other sites are being considered particularly around the outfall from atomic power stations and other industrial operations whose cooling systems discharge large volumes of warm water. Submersible cages which could be lowered to warmer depths when surface temperatures drop too low have also been proposed, as have systems which involve moving the fish to a warmer location in winter.

Water heated by warm cooling tower effluent should work, provided it has not been contaminated with water treatment chemicals. Submersible cages can be designed as proposed but their added cost might make them uneconomic until all of the suitable natural sites have been taken up. The same would be true of systems involving the transfer of the fish to a warmer or heated location for part of the year.

The New Brunswick government and Fisheries and Oceans scientists estimate that in New Brunswick there are between 50 and 100 suitable cage farm sites depending on the level of risk one wishes to assume for low temperature mortality. In early summer 1987 commercial development was concentrated in Charlotte County, New Brunswick where 32 sites comprising 425 cages were in place. In addition, two farmers were raising rainbow trout for fall harvesting in marine sites not suitable for wintering over.

In 1982 the total production of Canada's salmon aquaculture industry was about 300 tonnes, a large part of which was plate size coho salmon in British Columbia. The first significant commercial harvest of Atlantic salmon was in 1986 when 500 tonnes went on the market. This will increase to 1500 tonnes in 1987 and is projected to reach 5000 tonnes by 1990. In terms of value this will be worth $32 million and by the mid-1990s this could reach $100 million as the existing farms reach capacity and the remainder of the 50 "good" sites are developed.

Some of these sites are claimed to interfere with herring weir fishermen and there has been considerable controversy over the rights of each group. However aquaculture is seen as being a more profitable business - even a small 10 cage farm can generate revenues of $1 million per year - so some weir fishermen have traded their licenses and converted their weir sites to salmon cage sites with assistance from the provincial government.

Aside from these and other relatively small independent operators the industry in New Brunswick is dominated by two large corporate organizations and a few large independents most of whom have been in the industry since it began to develop around the beginning of this decade.

The corporate organizations are Sea Farm Canada Inc., a joint venture between Canada Packers and a Norwegian company, Mowi Ltd., and Connors Brothers Ltd., the New Brunswick based sardine processor and member of the Weston group of companies.

Sea Farm operates three hatcheries in New Brunswick with an annual capacity of over 2 million smolt. They also operate two grow-out sites including one in Maine and have plans for expansion. Connors Brothers is also building a vertically integrated salmon aquaculture organization based, initially, on an aquaculture feed business. They now have a hatchery and 44 salmon grow-out cages.

The larger independents which include, Fundy Aquaculture, Jail Island Salmon Ltd., Sea Fresh Aquaculture and Harbour de Lute Salmon have at least 165 cages among them. They and most of the smaller farmers belong to a marketing co-operative, Atlantic Silver Ltd.

In addition to Atlantic Sliver, the New Brunswick industry has also formed an association, the New Brunswick Salmon Growers' Association to represent the interests of the New Brunswick seacage industry, set product standards and lobby for funds. All of the seacage operators (presently 32) are expected to join this association. The first president and several members of this association are also members of an aquaculture task force set up as part of the Canada - New Brunswick Subsidiary Agreement on Industrial Innovation and Technology Development. One of the functions of this task force will be to facilitate private sector participation in planning for the development of technology required to advance aquaculture in New Brunswick.

Atlantic salmon aquaculture has received considerable scientific and technical support from Fisheries and Oceans which has an active aquaculture development program at its station in St. Andrews, New Brunswick and a demonstration farm at nearby Lime Kiln Bay. The demonstration farm evaluates and demonstrates aquaculture equipment, cages, feeds and operational techniques. The station at St. Andrews is engaged in more basic studies of the salmon biology, physiology and pathology. There are also private sector and university funded groups in the St. Andrews area carrying out research projects and providing services such as operator training to the industry.

Under its constitutionally delegated authority, the New Brunswick government regulates salmon aquaculture very closely and, in fact, imposed a moratorium on growth in September 1986. There was no immediate concern on the market side. They could sell all the salmon they could produce. The problem was that the growth of the industry itself had become disorganized. Supplies of eggs and smolt were out of balance with demand and future supplies were uncertain as were supplies of suitable feed. Furthermore there was no overall policy governing

foreshore use and the allocation of inshore water rights. This led to complaints from recreational and commercial users of coastal properties and adjacent water. The moratorium restraints are now being lifted as policies for a more orderly control of the industry are adopted.

In other parts of the Atlantic provinces and Quebec salmon aquaculture is less concentrated because culture conditions are less favourable and aquaculture ventures are directed more toward species whose growth cycle or temperature tolerance can accommodate to the winter climate.

VII. SALMON AQUACULTURE IN BRITISH COLUMBIA

Most British Columbia salmon farms raise both Coho and Chinook. Chinook grows to a larger size and commands a higher price per kilo but the Coho grows faster and has better disease resistance.

Both species are raised from eggs supplied by government hatcheries. The eggs are hatched and raised to the smolt stage in fresh water in about 8 months. The smolt are then transferred to salt water for grow-out. This can take from as little as 7 months for 300 gm pan-size Coho to 15 to 24 months for full size fish (2 to 2 kilos for Coho and over 3 kilos for Chinook).

There have been fish farms in British Columbia since the early 1970s but the commercially successful industry has developed only during the past 5 or 6 years. In 1984 production was less than 100 tonnes. In 1987 it was about 1,500 tonnes and in 1988 is expected to be 2,500. There are wide variations in estimates for the future but production of 16,000 tonnes by 1990 is possible based on the number of fish already in the water.

At present all grow-out is in net pens but a land based grow-out facility with a production potential of 1,000 tonnes per year is under construction near Nanaimo by a Norwegian-Canadian company.

In 1987 there were 120 operating fish farms in British Columbia. This figure will reach 150 in 1988 but estimates beyond this year vary widely. Most of the sites are on the Sechelt peninsula, around Campbell River or on the Gulf Islands. Areas for possible additional growth are around Port Alberni, Prince Rupert, northern Vancouver Island and on the Queen Charlotte Islands.

The product is primarily fresh dressed salmon with a significant quantity also going to smokers. The principal market is western United States but there is potential in Japan, France and Britain. Competition will come from U.S. domestic production and, in Europe, from Norwegian, Scottish and other European producers. At the present time demand exceeds supply but that condition will not continue much longer if current expansion plans in several regions of the world are even partially implemented.

Structure of the British Columbia Industry

Participants in the British Columbia salmon farming industry range from small independent farmers with two or three cages to large vertically integrated corporate organizations controlling several farms. At least seven companies are listed on the Vancouver Stock Exchange. The smaller firms usually have a marketing arrangement with one of the large salmon companies and have frequently pre-sold their inventory to their marketing agent in order to obtain working capital. Individual companies may also belong to a local association such as the Sunshine Coast Aquaculture Association and to the British Columbia Salmon Farmers' Association, (BCSFA). The function of BCSFA is to serve the collective interests of its members and has included the allocation of eggs and related operational tasks. In future it will probably assume a more active role in representing industry before government and in developing an industry-wide marketing strategy.

Financing aquaculture has been a problem, particularly in Canada, because the banking system has been reluctant to back an industry whose companies have such a long start-up period before beginning to generate revenue and the Bank Act has prevented the use of fish in the water (inventory in net pens) as collateral. In many cases Norwegian money, frequently tied to the purchase of Norwegian equipment, has supported new entrants. The land based grow-out facility being constructed near Nanaimo has a Norwegian partner and, in another joint venture, Canada Packers has joined with Sea Farm AS, of Norway to set up salmon farming production and marketing companies in both the Atlantic and Pacific regions. Another company, Pacific Aqua Foods Ltd., recently signed a financing and marketing agreement with National Sea Products Ltd. of Halifax and Aquarius Seafarms Ltd., in which there is a large Norwegian investment, recently completed an equity issue of over $5 million.

VIII. MARKETS AND MARKETING

The development of the Atlantic salmon aquaculture industry began in Norway in the early 1970s. Development of an aquaculture industry based on Pacific salmon began a few years earlier in Japan and western North America. After an auspicious start, with the raising of pan-sized Coho salmon, the North American industry floundered because the product could not compete with the less expensive, easier to grow rainbow trout. The coho was positioned as an alternative to the trout but the consumer did not perceive a difference in value sufficient to justify paying a higher price for salmon.

In Japan, where the objective was to produce a 2 to 5 kilo fish to supplement the capture fishery supply, development was slow while the technology was being developed and output was consumed domestically.

In Norway, and later, Scotland, where Atlantic salmon aquaculture was being developed the initial emphasis was on smoked salmon and the premium quality fresh salmon sold principally in the European market.

Rapid development of both the Atlantic and Pacific aquaculture industries began in the early 1980s and was supported by a widespread recognition of fish in general and fresh fish in particular as being wholesome and healthy foods. This led to an increase in consumption which has created a demand for farmed salmon in developed countries which has increased faster than supply.

As consequences of this, the selling of farmed salmon has not been a serious marketing challenge but the investment in new capacity has been increasing at a rate that must soon tax the ability of the market to absorb the output at a price that will support a viable farming industry.

Information complete enough to permit a reliable market analysis has not been collected but a number of conclusions seem apparent.

1. The market for fresh salmon is not open ended. It is limited ultimately by the number of meals served and constrained more immediately by the share of that market that can realistically be held in competition with meat, poultry and other fish.

2. Cost of production and distribution will limit the extent to which price can be used as a lever in maintaining and increasing that share.

3. Because of the significance of transportation costs in the delivered price of fresh fish, Norway will have a relative advantage in Europe. Atlantic Canada will have an advantage in eastern North America and British Columbia in western United States.

4. Product forms and presentations other than fresh dressed or smoked salmon need to be developed to expand the market and to provide protection against single product market fluctuations.

   Marketing Channels: In both British Columbia and New Brunswick the large corporate organizations (Canada Packers/Sea Farm and Connors) have their own established marketing infrastructure. Pacific Aqua Foods Ltd. of Vancouver also has announced a new financing and marketing agreement with National Sea Products which will have the same effect. Smaller companies on the east coast, where there was no existing salmon industry of consequence, have formed their own marketing company to sell their product. On the west coast, where a salmon processing and marketing industry already existed, the independent salmon farmers tended to sell their product through one of the older companies. Recently the British Columbia Salmon Farmers' Association began to organize a marketing and promotional program for its members. They are considering a common brand name, labelling and promotional material and the enforcement of a quality standard. Centralized selling could also be adopted.

Although each individual company or sales agent undoubtedly knows the identity of his customers and each has a basic understanding of the nature and scope of his market, there is no comprehensive picture of the total market, (even in the United States where Canada's greatest potential lies), good enough to be used as a basis for planning, executing and monitoring a marketing strategy. Not only would a study to provide such a picture help to protect our existing business and exploit opportunities for its growth, it could identify and priorize opportunities for new products which will be needed to support future expansion and growth.

The need for product diversification is acknowledged by most producers but only a few give it the priority required to stimulate any activity and even these lack the market intelligence to permit more than intuition in choosing areas for development.

As a result there is virtually no Canadian product development effort related to the salmon aquaculture industry.

To illustrate the importance of market expansion and product development, the following tables show the anticipated relationship between supply and demand by 1990. The tables themselves are a composite of figures from several sources that use different assumptions concerning the impact of market forces. The demand table, in particular, which was prepared by the Resource Policy Group in Oslo in 1986 for the Royal Norwegian Council for Scientific and Industrial Research, acknowledges a possible error of plus or minus 25 percent. This is indicative of the uncertainties arising from incomplete knowledge of how the market and, indeed, the industry, will respond to changing competitive conditions. Taken together, the two tables should alert one to the pressures that are going to bear on price and on customer service, product quality, market intelligence and cost efficient operation.

Farmed Salmon Production
(metric tonnes)

	1986	1987	1990
Norway	45,500	55,000	65,000
Scotland	9,000	14,000	15,000
Other Europe	4,300	8,000	20,000
Chile	1,000	1,500	3,500
New Zealand	500	1,500	3,000
Japan	5,000	6,000	9,000
U.S.A.	2,300	2,500	8,000
British Columbia	1,000	2,500	16,600
New Brunswick	500	1,500	5,000
World Total	**70,000**	**93,000**	**150,000**

Farmed Salmon Demand - 1990
(metric tonnes)

France	28,000
West Germany	22,000
Great Britain	15,000
Other Europe	15,000
U.S.A.	30,000
Japan	10,000
Total	**120,000**

(Prepared by Resource Policy Group - Oslo)

IX. AQUACULTURE OF OTHER SPECIES

This report has covered only the aquaculture of salmon but, as indicated in the background section, other species of fish and shellfish are raised commercially or are under development for commercial culture.

1. Rainbow trout (Salmo gairdnerii) are raised in freshwater ponds within delivery distance of major metropolitan centres where they are supplied fresh to the hotel and restaurant trade. Because they can be raised to plate size in one season they are also grown in marine cages in locations where winter water temperatures are too low for over-wintering and by salmon farmers who want to generate some revenue during their start-up cycle while waiting for the first crop of slower going salmon to mature. Salmo gairdnerii raised in salt water is also called Steelhead trout or Steelhead salmon.

2. Arctic char or charr (Salvelinus alpinus), also called Salmon trout, is raised commercially in Europe and at least one New Brunswick farm has some in cages. Because it grows well in cold water (but still subject to the -0.7°C lethal limit) it is an attractive option for areas where salmon grows slowly. Major work on systems design, nutrition and disease control of Arctic charr is being conducted at the Freshwater Institute in Winnipeg and researchers at St. Andrews, New Brunswick are crossing charr with Atlantic salmon seeking to get a fish with the better features of both.

3. Mussels are raised commercially on both the Atlantic and Pacific coasts. The Prince Edward Island industry is the most developed but the other Atlantic provinces, Quebec and British Columbia also have commercial farms.

Cultured mussels are preferred to wild ones because the practice of growing them on strings or socks suspended from rafts or buoys yields a better quality product, free of sand particles and miniature pearls which are found inside the shells of wild mussels growing on the bottom.

4. Oysters are also cultured on both coasts using a technology similar to that employed for mussels. Attempts to raise oysters in southern British Columbia about 10 to 15 years ago were a commercial failure because of disease problems but current operations, based on a better understanding of the technology, are more successful. Now there are successful oyster farms in each of the Atlantic provinces and Quebec as well as British Columbia.

5. Scallops are being cultured experimentally but no significant commercial development has been achieved yet. Anticipated shortages of wild caught stock is stimulating interest in scallop culture.

6. Lobsters can be raised through their complete life cycle using a Canadian developed technology but it is too expensive a process to be commercially competitive in Canada where wild stocks are available. However, Canadian companies have developed commercially viable culture techniques for growing small lobsters to commercial size and for influencing the moulting cycle so as to extend the marketing season.

7. Cod, halibut and other groundfish are being studied experimentally as potential aquaculture species by some countries including Norway and Canada. Results to date indicate that feasible techniques can be developed but that commercial viability is at best marginal. However, premium grade groundfish will probably be commercially available in 12 to 15 years.

8. Marine plants or seaweeds are harvested in many parts of the world for the extraction of gums and other chemicals and as items for direct consumption. Some marine plants are cultivated to obtain premium grade product or to augment wild harvest supplies.

   In Canada, workers at the National Research Council station in Sandy Cove, Nova Scotia identified rapid growing strains of Chondrus crispus (Irish Moss) which produced a high yield of a commercially sought after grade of carragheenan. The culture technique has been reduced to commercial practice and a producing farm has been established in Nova Scotia.

X. GOVERNMENT ASSISTANCE TO AQUACULTURE IN CANADA

Through the Department of Fisheries and Oceans the Canadian government provides several forms of assistance to the aquaculture industry.

1. Most of the fry or the eggs from which they are hatched are supplied by government hatcheries. These government hatcheries were established to supply the government re-stocking and resource enhancement programs. The government does not want to be a supplier to the commercial aquaculture industry and will

withdraw from this activity as private sector hatchery capacity to meet demand is developed.

2. The federal government maintains a regulatory framework to control disease, protect the genetic integrity of the stocks (both wild and cultured) and generally to manage the quality of the product. Controls are particularly stringent in the import or interprovincial shipment of eggs or live fish. This policy has frustrated some growers who were having difficulty obtaining eggs locally or who wanted to experiment with new strains but has been vindicated by the low incidence of disease within the Canadian aquaculture industry.

3. To back up this regulatory system the federal government conducts or sponsors a number of research programs in fields related to salmon culture genetics and disease control.

In the division of federal-provincial relations, the management of aquaculture is a provincial responsibility and is excluded from most federal programs providing direct financial aid. Exceptions are programs where federal funding is administered by the province, special programs available only to Indian, Inuit or Métis groups and certain regional programs where aquaculture has been made eligible through a bilateral agreement with the province(s) involved or projects, such as feed development, which are part of the total aquaculture system but are not, of themselves, fish farming activities.

Forms of assistance include low interest loans, loan insurance and direct grants but the types of assistance and eligibility criteria will vary from one region to another in response to local needs. A businessman considering the establishment or expansion of an aquaculture operation should consult with his regional DRIE office where applications for DRIE program assistance can be processed and information on other federal programs and those of provincial governments obtained.

DRIE programs, some of which are now administered by the Atlantic Canada Opportunities Agency and the Western Diversification Initiative include:

- Atlantic Enterprise Program which provides insurance and interest rate reduction on loans to finance new or expanded production capability including aquaculture;

- Enterprise Cape Breton which increases the government support level for industrial development projects in the Cape Breton region and extends eligibility criteria to include aquaculture;

- Complementary Program for the Industrial Development of Eastern Quebec which provides increased support for industrial development projects including aquaculture, in the Gaspe' Peninsula and Magdalen Islands.

In addition there are subsidiary agreements between DRIE and the individual provinces and territories under the Economic and Regional Development Agreements which provide for financial assistance for development in designated industrial sectors. Aquaculture projects are included in the subsidiary agreements with British Columbia and the Atlantic provinces.

Special assistance is also provided by DRIE to native groups including Indian, Inuit and Métis under the Native Economic Development Program. Aquaculture projects are eligible.

Other federal departments and agencies have programs to help fulfill their particular mandates. Many of these, such as Technology Inflow Program (External Affairs), Industry Energy Research and Development Program (Energy Mines and Resources), and Industrial Research Assistance Program (National Research Council) could supply assistance to certain activities of some aquaculture development projects.