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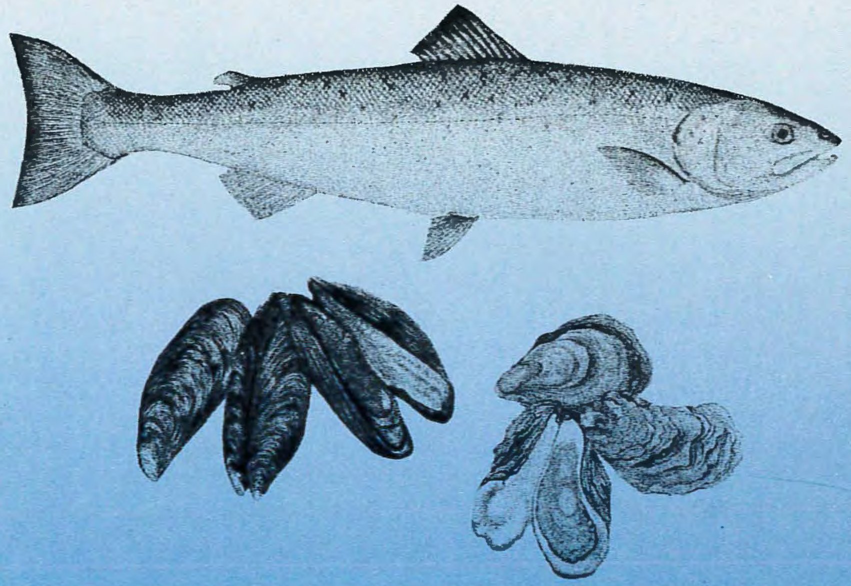

AQUACULTURE WORKSHOP
CHARLOTTETOWN, P.E.I.
FEBRUARY 10-12, 1987

Canada

Fisheries and Oceans
Pêches et Océans

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ATLANTIC CANADA AQUACULTURE WORKSHOP
Charlottetown, Prince Edward Island
February 10-12, 1987

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TABLE OF CONTENTS

VOLUME II

SALMONID CULTURE

APPENDICES

ABSTRACT

Roache, J. F. (ED.). 1987. Atlantic Canada Aquaculture Workshop - Proceedings. General Education Series #5; Vol.I; 229p.; Vol.II; 191p.

This publication contains the proceedings of the Atlantic Canada Aquaculture Workshop held in Charlottetown, Prince Edward Island, February 10-12, 1987. Sponsored under the Atlantic Fisheries Development Program of the Department of Fisheries and Oceans, the Workshop brought together by invitation approximately 175 resource persons and participants representing two levels of government (federal and provincial), the aquaculture industry and several research institutes from across the region. While the fundamental purpose of the Workshop was to serve as a technology transfer exercise, an equally important objective was to develop a consensus among participants concerning the future direction of research and development and related initiatives within the salmonid, mussel and oyster sectors of the industry in Atlantic Canada.

RESUME

ROACHE, J.F. (ED). 1987. Atelier Atlantique sur l'Aquaculture. Education générale. Série no. 5; Vol.I; 229p.; Vol.II; 191p.

Cette publication comprend les Actes de l' Atelier Atlantique sur l'Aquaculture, qui s'est tenue à Charlottetown à l'Ile du Prince Edouard du 10 au 12 février 1987. Parrainée par le programme de technologie des pêches de l'Atlantique, Ministère des Pêches et Océans, l'atelier a réuni sur invitation environ 175 experts et participants représentant deux niveaux du gouvernement (fédéral et provincial), l'industrie aquicole et les instituts de recherche de la région. Tandis que l'objectif principal de la conférence a consisté en un exercise de transfert de technologies, un autre, d'egale importance, a visé l'établissement d'un accord parmi les participants en ce qui concerne l'orientation future de la recherche et du développement ainsi que des initiatives connexes au sein des secteurs des salmonides, moules et huîtres de l'industrie du Canada Atlantique.

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Prepared by the Holland College, Division of Renewable Resources with technical advice from Tom O'Rourke, Industrial Technology Advisor, National Research Council, Charlottetown, Prince Edward Island.

NOTICE

INTRODUCTION

On February 10-12, 1987, the Department of Fisheries and Oceans (DFO), in co-operation with the Conference Bureau at Prince Edward Island's Holland College, hosted an Atlantic-wide, industry-government Workshop on Aquaculture. Another milestone in technology transfer under the Atlantic Fisheries Development Program, the Workshop was the second in a series to be sponsored by the Department during the first quarter of 1987.* It brought together, despite one of the worst winter storms of the season, approximately 175 delegates from all across the five Atlantic provinces. Included, in addition to aquaculturists from the salmonid, mussel and oyster sectors, were representatives of the research, education and training establishments and of both levels of government - federal and provincial.

The Atlantic Canada Aquaculture Workshop was really a three-in-one proposition. In addition to plenary, luncheon and dinner sessions involving all participants, separate sessions for each of the different sectors were held simultaneously over much of the three-day period. The Workshop had among its objectives to:

- provide a forum for exchange of new and appropriate technologies for aquaculturists in Atlantic Canada;

- obtain feedback from aquaculturists with respect to their needs, problems, and development constraints;

- assist in determining future research and development priorities geared toward better resource enhancement; and

- seek new directions for expansion of the aquaculture industry in Atlantic Canada.

* Note: The other two workshops in the series include one on Surimi Development, held in Clarenville, Newfoundland - January 28/30, 1987 and one on Technology Transfer in Grande Rivière, P.Q. - March 9/11, 1987.

In announcing the Workshop, Fisheries and Oceans Minister Tom Siddon said: "This Workshop could not be more timely given that the Department is currently negotiating agreements affecting the commercial development of aquaculture with the various provinces....The time has come for us to pause, to take stock of recent developments, to compare experiences and to map out a strategy to allow us to take full advantage of the opportunities available through aquaculture." The Atlantic Canada Aquaculture Workshop, then, was intended as the DFO contribution to the ongoing process of defining a rational development strategy for this expanding segment of the industry.

At present, aquaculture in Atlantic Canada generates approximately $9 million a year in total revenues. The potential exists to increase the value of these fisheries by as much as 30 times within the next decade. Salmon farming in the Bay of Fundy area, for example, has grown in value tremendously in recent years. The market for cultured mussels, meanwhile, appears very promising; the rate of new entrepreneurs entering the sector continues to increase rapidly to meet a growing demand. And oyster production, while subject to environmental constraints and seed shortages in certain areas, shows every indication of achieving its former levels of productivity.

The objective of an efficient, profitable industry has two dimensions. The first is the research effort, which is well in hand in Canada. The second is the development effort -- the transition from the experimental setting to the commercial environment, which remains an area of great potential. It is here that the Atlantic Fisheries Development Program, other government agencies and programs, and entrepreneurs from throughout Atlantic Canada can make a great contribution. Aquaculture will only mature as an industry when development-oriented entrepreneurs match the lead already established by the scientific community.

Commercial aquaculture draws from the scientific community a variety of benefits ranging from research and development in such fields as fish health, disease prevention and control, nutrition and diet formulations, genetics and stock selection, growth and reproductive physiology, and the optimization of biological systems. The development community will continue to provide technology-related R & D, technical information and advice, and selective capital assistance. However, a development strategy must emerge, and this was, in fact, the rationale behind the Department's convening the Atlantic Canada Aquaculture Workshop.

Salmonids - What emerged loud and clear from the salmonid sessions was the requirement for a deliberate approach to development of the sector. Of particular interest to the Atlantic Fisheries Development Branch is the continuing need to investigate new markets, new products, new equipment and new technologies required to fish-farm successfully. A great opportunity also exists for the dissemination industrial intelligence to producers throughout Atlantic Canada.

Specifically, technological development must include:

Increased Hatchery Productivity

- the design and evaluation of equipment for the supply and circulation of water;

- tank design, with a view to increasing load capacity (including tank shapes, water circulation systems, filtration systems, etc.);

- upgrading growing and harvesting methods and techniques, using innovations developed in Canada and abroad.

Over-wintering Techniques and Technologies (and related R & D)

Shore-based Tanks versus Sea Cage Technology

- economies of each;
- escapement considerations;
- infrastructure technology;
- investigation of alternate species (e.g. eels, trout, etc.).

The Atlantic Fisheries Development Program, therefore, has an important role to play, together with industry and other government agencies in three distinct facets of an evolving aquaculture strategy:

- the transfer of already-established commercial technologies and techniques to Canada from abroad;

- research and development programs to create indigenous commercial technologies; and

- technology transfer and industrial training programs to ensure that the latest information and know-how is diffused throughout the industry in Atlantic Canada.

But all of the organizations -- federal, provincial, institutional and private sector -- represented at the Atlantic Canada Aquaculture Workshop have an important job to do: to ensure that this burgeoning industry comes to fulfill its obvious potential -- quickly, efficiently and effectively.

The quantity of material is such that these Proceedings are presented in two separate volumes. Volume I contains the Mussel/Oyster presentations and related material. Volume II is devoted strictly to salmonids. They can, therefore, be reviewed individually or as a set, subject to the specific inclinations of the reader.

About 175 participants from industry, government and the research institutes from throughout the Region attended the Atlantic Canada Aquaculture Workshop in Charlottetown, P.E.I., February 10-12, 1987. This was the Opening Session (Plenary) in which the RDG, Gulf Region, addressed participants, substituting for Pat Binns, Parliamentary Secretary to the Minister of Fisheries and Oceans.

The RDG, Gulf Region, Eugene Niles (above) introduced Peter Hjul (below), Publisher, Fish Farming International, guest speaker for the Banquet. Mr. Hjul spoke on "International Aquaculture". Head table guests for the occasion were representative growers from each of the five Atlantic provinces.

OPENING ADDRESS

by

Eugene Niles

Director General, Gulf Region, Fisheries and Oceans

(on behalf of Fisheries and Oceans Minister,

the Hon. Tom Siddon

and

the Minister's Parliamentary Secretary,

Pat Binns, M.P.)

I welcome you to the first comprehensive Workshop on Aquaculture for Atlantic Canada. We have here today about 130 aquaculturists, along with representatives of schools and universities, and federal and provincial governments. In this room are the pioneers of a new Atlantic industry. We will be joined by others for tomorrow's sessions.

At this Workshop, you will exchange information. You'll discuss the tricks of the trade. You'll talk about future directions for government and industry. And you'll try to come up with some new keys to success -- for each of you and for the industry in general.

What are the secrets of success? You're the experts on the technical side. But maybe it's worth taking a quick look at the underlying factors that give technology a chance to work.

Atlantic Canada would seem the perfect place for aquaculture to take off. The seacoast swarms with life. We've got hundreds of unpolluted bays and thousands of miles of shoreline for aquaculture. We're in a well-off, well-educated, industrialized country, and we're next door to the world's single greatest market for quality fish.

But given the past record of Atlantic aquaculture and the Atlantic fishery in general, we could well ask ourselves a few questions. How long will the present growth continue? Will we cope with competition from overseas and in the United States? Will we develop the quality and service, the associated businesses, the whole industrial structure that builds a world reputation and attracts world business?

Our long-term success is far from being a simple matter and far from being certain. In thinking about our own future, perhaps we should glance at the way in which aquaculture developed in other countries.

Probably the best-known success stories are those of Norway and Japan. In the last 10 or 15 years, Norway has moved from almost zero production in Atlantic salmon to perhaps 35,000 tonnes, with future projections of 100,000 tonnes. That's far above the normal catch by our own huge fleet of four or five thousand vessels fishing wild salmon on the Pacific. Over 500 Norwegian salmon farms now employ more than 2500 people, most of them doing well for themselves.

What did Norway have going for it? In the first place, good resource and environmental conditions, a fish-rich coast and ice-free fjords.

But if aquaculture fits Atlantic Canada so naturally, why have we been slower getting started than certain other nations? And why did a number of our earlier attempts end in failure?

A hundred years ago, the federal Department of Fisheries set up dozens of hatcheries across the country, for salmon and other species. People were hypnotized by hatcheries. Fish culture seemed to be the secret of abundance and prosperity. But by the 1930's, scientists found that the hatcheries had made little difference, and many of them faded away.

Since then, the world has learned a lot more about aquaculture - about diets, about health protection, and about handling the different species. Canadian biologists and engineers made an important contribution. By the end of the 1960's, we had a much greater knowledge base. Accordingly, in the 70's, several large pioneering ventures started up on both the Atlantic and Pacific coasts -- only to collapse, for a variety of reasons. So, too, did a number of small ventures.

But people kept pressing on, and today aquaculture looks promising. For example, mussel farming on Prince Edward Island and salmon farming in southern New Brunswick are now doubling production every year.

Business conditions also helped. Although Norway has only a small population, it has a strong marine and fisheries infrastructure - the boat-builders, net manufacturers, and associated industries to develop and maintain marine technology. Norway also has good transportation, a strong business community, and the markets of Europe nearby.

Besides good environmental and business climates, Norway had the right people doing the right things. The Norwegians began with a high regard for fish. They handle it with care and appreciate its value. Their tradition of trout culture made it easy for them to switch to salmon culture. The Norwegian government aided salmon farmers with research, selective breeding, provision of eggs and smolts, and general encouragement.

Norway, however, had its own failures in salmon farming; but the entrepreneurs kept at it. They found out what worked. They set up a fish-farmers' sales organization and a smooth system of transportation and marketing. And, in the last 10 years, they have created one of the world's great success stories in aquaculture.

How about Japan? The Japanese successfully culture salmon, scallops, seaweed, you name it. They, too, had a rich sea with the right environment. As for the business environment, Japan has a large population and an insatiable demand for fish. Again, the infrastructure was in place, including everything from transportation to traditions of entrepreneurship, and a strong network of fishing co-operatives along the coast. Also, Japanese companies tend to work together on new developments.

Like the Norwegians, the Japanese started with a high regard for fish and its value, and a tradition of husbandry. Over the decades, the Japanese made a special effort to import, absorb, and re-develop aquacultural methods. The government carried out extensive research, and also maintained a large network of experimental stations to try out new fishery methods. They kept at it until aquaculture began to click. Now, they are the world leaders.

How does Canada compare with these two countries? Our Atlantic coast has loads of fish, but, in some ways, the environment is worse. We face the great enemy of winter. Cold water slows fish growth. Ice destroys nets and pens.

So, what is the key to success? Everyone acquainted with aquaculture keeps coming back to the same point. A good natural environment helps. A good business environment helps. But, just as in Norway and Japan, in the end, it's the people that count, the entrepreneurs themselves and the people in government and industry who work with them.

Depending on the people, aquaculture can fail, even when surrounded by rich waters. Or it can succeed, even when starting with nothing except energy and an idea (like the catfish farmers in the United States, for example).

So what are we, as Canadians, doing to match our competitors? In fact, we have done a lot.

On the government side, our researchers have learned a great deal about how the fish live and how to keep them alive. Indeed, the Norwegians have learned a few things from us. To put our research knowledge to work, federal and provincial governments have published, they have preached, and they have undertaken many pilot projects.

Aquaculture in Atlantic Canada has tended to develop where the federal or provincial governments, usually both, were putting forth a strong effort. Examples include the salmon farms in southwest New Brunswick near the St. Andrews Biological Station, the mussel and oyster farms in eastern Nova Scotia, and shellfish and finfish culture on Prince Edward Island. The federal-provincial ERDA agreements on fisheries have helped greatly. So has the work of DFO's Atlantic Fisheries Development Branch, and that of the provincial agencies.

Projects in every province have emerged from government-industry co-operation, and government contracts have assisted private-sector research. Besides cross-fertilization of fish, there's been cross-fertilization among government and industry people.

The entrepreneurs themselves have made things work in the water. They've coped with wind, waves, ice, and the sometimes seemingly inexplicable demands of bureaucracy.

Here again, the federal Department of Fisheries and Oceans is trying to help. We have made an agreement with Nova Scotia, and we are negotiating agreements with other provinces for a simpler system. The intent is to have the provinces deal with most of the day-to-day administration, and thereby give aquaculturists faster service on licences.

Canadians in government and industry have indeed done a lot, and it shows in the statistics. As I noted, salmon production in southern New Brunswick is doubling yearly. More than two dozen farms have started up. Last year, they produced four or five hundred tonnes, worth perhaps $5 million. This year, the total could exceed $10 million.

In Nova Scotia, more than 50 "fish-farmers" grow mussels. More than a dozen grow European oysters. On Prince Edward Island, the mussel industry is overtaking the oyster industry, and starting to provide a good living to entrepreneurs. Scallops in Newfoundland, trout in Quebec -- every province has entrepreneurs who are starting to make a living from aquaculture, and rapid growth is continuing.

So we've come a long way, but we have a long way to go, with a lot of worries en route. We face strong competition from other countries, and we face special problems at home. Remember the things that weakened our wild-fish industry for so many years -- distances, isolation, fragmentation, problems of communication and co-ordination, and lack of responsiveness to the market. Will those same old problems haunt aquaculture? Or will you work to overcome them from the start?

As the lead federal agency for aquaculture, DFO, led by the Minister, the Honorable Tom Siddon, has consulted extensively with provincial governments during the past year. This has led to a consensus on aquaculture development. We are increasing federal co-operation to ensure development that is orderly and complementary to the wild fishery. Both levels of government will work together to encourage more production, higher value, reliable supply, and a strong, stable, technologically-advanced industry. The Premiers and Prime Minister have strongly endorsed aquaculture development.

But, for the most part, our government likes to let industry take the lead, while we act as a facilitator, providing support in some key areas such as research. We have increased consultation in every phase of the fishing industry -- lobster workshops, scallop workshops, technology workshops, new advisory systems, you name it.

With our belief in aquaculture and our belief in consultation, we have a double reason to take this Workshop seriously. And you, as pioneers, have a chance in this Workshop, and outside it, to put your own stamp on the future, shaping attitudes, forming directions for government and yourselves, and building well from the beginning.

I believe that you have the potential to make a good beginning. Except in the oyster industry, unlike the Norwegians and Japanese, you had little tradition of aquaculture on which to build. Yet, you have managed to make things work -- notwithstanding the lack of experience and notwithstanding some special problems unique to Canada.

You are pioneers and you have the nature of pioneers. You look outside your own locality, you gather knowledge from elsewhere, you try new ways of doing things, and you persevere until everything comes together and works right.

To make the aquaculture industry grow, you will have to apply that same approach on a wider scale. Because of the nature of the Atlantic coast, communications and coordination are always going to be special problems for you, just as they have been in the wild fish industry.

At this Workshop, you will, as I mentioned, exchange tricks of the trade amongst yourselves. But you also have a chance to think about the whole industry, and how the parts fit together.

Atlantic aquaculture is still really just getting started. Its future course is still unclear. And it is you, not government, who will do most to shape that course.

You can think about passing on your expertise to others, as eventually you will have to do, if we're to have a strong industry. You can think about all the ways to create more production, steadier channels of supply, top quality, good marketing, and strong associated businesses. You can think about the co-ordination, the communication, and the critical mass that a strong industry must have. And in so doing, you have the potential to make Atlantic Canada the most diversified and flourishing aquaculture centre in North America.

So to conclude, at this first comprehensive Workshop on Atlantic Aquaculture, you have more to think about than growing fish. You need to think about growing an industry. And the main key to success for that industry, now and for years to come, is you, yourselves.

SALMONID CULTURE
WORKING SESSIONS

INTERNATIONAL AQUACULTURE

by

Peter Hjul
Editorial Director,
<u>Fish Farming International</u>
London, England

The farming of fish, molluscs, crustaceans and seaweeds is estimated to produce between 9 and 11 million tons of food a year. There is no precise figure because aquaculture has yet to inspire the attention which statisticians have been giving the traditional fisheries.

The Food and Agriculture Organization (FAO), a few years ago, calculated an annual farm harvest of around ten million tons. But only a few months ago we were caught up in an argument between FAO and an international research and development organization in the Far East. One of its economists queried figures given to the FAO by China and India. He suggested the figure for China was an overestimate of 131 per cent and that for India, 502 per cent. Both parties appear now to have settled their differences and I mention the argument only to give you an example of how much we can diverge in establishing production figures.

FAO does compile a much more reliable set of figures for overall aquatic production, including fish farming. Its world total for 1985 was just over 85 million tons. Last year may well have seen an increase to around 87 or 88 million tons. Assuming about 11 million tons for all farmed species, plus seaweeds, we find that aquaculture is at present providing 13 per cent of all aquatic production.

Not so many years ago, we had confident predictions that the fish supply at the turn of the century would comfortably exceed the 120 million tons a year necessary to maintain the seafood share of the worldwide protein diet. With the demand for fish growing and, we trust, dietary standards improving, the demand by the year 2000 should be considerably more than 120 million tons. But, without some momentous discovery of new stocks or a remarkable breakthrough in farming, the aquatic harvest by 2000 is likely to be well short of that. It may be around 110 million tons.

Within this total, the tentative estimate for aquaculture is 22 million tons. This was made last year by Dr. Colin Nash, who heads the Aquaculture Program in the FAO. He was trained in the hard school of British marine farming, has worked in warm and coldwater aquaculture, and is not given to wild gazes into crystal balls. He qualified his estimate by saying that molluscs and seaweeds would account for a substantial share of the harvest; so, too, would culture-based fisheries enhancing natural resources in the open sea, in lakes, and in rivers and reservoirs. Ranching and fishery enhancement will play an increasing role in boosting traditional supplies. Much of the technology will emerge from farm work on hatcheries, feeding and disease; and I hope fishermen will take note of this when they feel threatened by aquaculture developments.

Assuming we reach 22 million tons, aquaculture will then enjoy a 20 per cent share of total production. We should remember this when next we are told that fishing is finished, and that the future belongs to farming.

Fishing is far from finished. As our knowledge of stocks has progressed and, as governments have established more protection, I believe that, overall, we are improving the resource. In many countries, including yours and mine, our fisheries are generally in a much better state now than they were 10 years ago. We can expect them to remain so. Farming, therefore, is a useful addition to our seafood supply, but with some notable exceptions, it is <u>no</u> substitute.

One exception, of course, is in the production of some salmonids. Another is the channel catfish in the U.S.A. We must also include the farming of mussels and oysters, which is proving a better and more reliable source of these seafoods than does gathering them from the wild. With the spread of scallop culture from Japan, we might also eventually place these among the species better supplied from farms than hunted in the wild.

Then, there is the tropical prawn. The world supply of prawns or shrimp from all areas, cold and warm, now amounts to about 1.8 million tons a year. The coldwater prawn or pink shrimp is a slow-growing small animal and is not likely, for a long time, to be a candidate for farming. But the tropical penaeid prawn can yield two or more crops a year. It has long been a traditional farm product in Southeast Asia. Most farming has been in vast ponds in estuarial or paddy areas, using natural fertilization and with stock obtained by collecting wild post-larvae.

This culture gives 300 to 500 kg per hectare and accounts for most of some 120,000 to 130,000 tons of tropical prawns a year from farming. But the prawn-fishing countries are — almost all of them — reaching the limit of safe exploitation of natural stocks. For many, farming is the only way they can increase supplies to meet steadily rising demand.

There is also a constraint on farm expansion based on wild seed (or even spawners) and natural feeding. Intensive culture is coming into prawn farming. Hatcheries are being set up in Ecuador, Taiwan, India and several other countries. This is an evolving technology and is set to become perhaps the most important development in aquaculture over the next decade. By 1987, the prawn may well have passed the Atlantic salmon as the most valuable species in aquatic farming. Farm totals of 400,000 tons and more are already being confidently forecast. They may even go comfortably past this, if hatcheries and feed suppliers support intensive farming with yields of two or three tons/ha and two crops a year.

But it is the Atlantic salmon that is setting the pace in aquaculture in northern Europe. Much of this Workshop concerns the technology and economics of this remarkable development.

To bring you up to date, the Norwegian industry in 1986 exceeded all expectations, producing a record 45,500 tons of salmon and 4,000 tons of sea-grown trout. The value of this harvest, from some 600 farms, was the equivalent of $340 million, putting farmed salmon far above cod and shrimp as the most valuable species produced by the top fishing nation in Western Europe.

Add to this harvest, about 9,000 tons from Scotland and about 2,000 tons from Ireland, Iceland and the Faroes, and we have a 1986 production of more than 56,000 tons. Farm production of sea-grown and portion-sized freshwater rainbow trout in the whole of Europe is estimated at about 190,000 tons a year.

Within the world total, these figures may seem relatively small, but they represent enormous value for industrial-scale, intensive aquaculture. These are the money crops which attract the investment, stimulate the technology and, unfortunately, arouse the resentment of those forced to watch on the sidelines as farms spring up and cages dot once-uncluttered coastlines. The very success of farming is bringing its own penalties, not the least of them, the problem of selling the harvest and maintaining prices on which costs were based when the farms were started.

Only last week I was told at the International Food Exhibition in London that Norwegian salmon could be bought on the Billingsgate market, if it was taken in some volume, for well below $2 per pound. When you have fish in your cage, and it has been there for two years or so, you need to sell it. This rush to market has tended to take place towards the end of the year, and the gluts and the lower prices reflect the influence of "salmon success". After all, before farming, the wild Atlantic salmon catch was between 8,000 and 10,000 tons a year.

This year the organizations serving Norwegian farmers say the increase will slow down, to about 8,000 tons for a total of 53,000 to 54,000 tons. But until a few months ago, the 1986 total was expected to be about 40,000 tons. For some time, Norwegian farmers suffered from a shortage of smolts, but greater hatchery capacity may upset forecasts of slower growth.

Scotland should produce 14,000 to 15,000 tons in 1987, and we could see 8,000 tons from Ireland and other countries. From Europe alone, therefore, the 1987 salmon crop could be around 65,000 tons.

With increasing hatchery capacity, more farms and higher output from existing farms, Norway could be producing about 75,000 tons in 1988. Scottish production may then be about 20,000 tons and we could expect another 10,000 tons from other countries, for a total of more than 100,000 tons!

The industry is thus well on course for a 1990 production of more than 120,000 tons and possibly nearer to 150,000 tons. A market study in Ireland last year indicated this could be 20,000 tons more than expected demand. If so, prices must tumble if the fish is to sell and find new outlets. This, in turn, must force the less efficient farms out of business, but I doubt if it will seriously cut production.

As the Irish study observed, until now, salmon has not been eaten primarily to satisfy hunger. It is a prestige commodity. But at the price of cod or below, salmon is going to have to capture a different market. This fish will move off the table of the gourmet to become an available, reasonably priced dish for everyone who can now afford a steak, a cod fillet or even a fish stick.

This, in my view, will be one of the fish farmer's greatest contributions.

Where can we expect the Atlantic salmon increase to stop? Only a few years ago, 100,000 tons was thought to be a far-away limit. The Irish study sees the technical maximum as 250,000 to 300,000 tons for Europe. One obvious limiting factor is the supply of feed required in intensive farming.

At a conversion rate of two tons of feed to a ton of harvested fish, 1986 production will have used about 110,000 tons. These feeds average about 60 per cent fish meal, or 66,000 tons. And, at the usual reduction rate, that meal came from a catch of 330,000 tons of capelin, herring and other fish.

This is a figure worth remembering when the traditional fishery next hits out at aquaculture or tries to curb its growth. Far from being a competitor to most fishermen, aquaculture could be one of their best outlets for surplus fish.

Feed manufacturers are playing their own vital part in the development of aquaculture. From a small adjunct to their other supply activities, it has grown into a prime market for companies with the foresight to provide for its special requirements.

With trout farms an even bigger consumer than salmon farms, we can expect the demand from salmonids alone to exceed 600,000 tons in Europe within a few years. While soya meal and some other protein sources may make progress, I cannot see the fish base being substantially eroded.

On a quick calculation, therefore, about 350,000 tons of fish may be needed for aquaculture, and that will have to come from 1.75 million tons of raw material. Take it a step further to 300,000 tons of salmon and 200,000 tons of trout, and the 600,000 tons of meal in a million tons of feed will require a catch, for farming alone, of three million tons.

Advances in technology will, no doubt, improve feed conversion rates, and we will get fish substitutes. But I can see fishermen and fish farmers linked together for many years to come, as supplier and consumer.

One of the less-publicized reasons why Atlantic salmon farming has progressed so rapidly is that the diseases once expected to afflict growers and hatchers as they produced more and more fish have proven far less devastating than feared. There have been some problems with furunculosis, and the Norwegians have had to combat Hitra disease. But overall, farmed salmon have proved to be remarkably healthy and resilient animals.

This should not lull us into a complacent illusion of security, however. We, after all, are taking a wild carnivorous animal out of its natural environment; we subject it to the stresses of closed environment; and we vastly increase the progeny from a limited genetic base. It could all blow up in our faces. It has not done so, and we are fortunate.

The Norwegians are now working to reduce the risk by setting up a selective breeding program for salmon and trout. From being a wild creature in danger of extinction, the Atlantic salmon is now on its way to becoming domesticated, and selective breeding will help this process.

Another feature of industrial-scale aquaculture is the technology it is stimulating. In only 15 or so years, aquatic farming in many parts of the world has evolved from a cottage-type, hands-on activity to a sophisticated, highly-technical operation. There has been marked progress in farm engineering, in structures, and, most recently, in computer-assisted monitoring and control of farms. This was made strikingly evident at a conference in Trondheim last year when speakers described complete systems run by one or two people from a control console.

Where labour is in short supply and expensive, as in many parts of Norway, this may be the way to go. But in the highlands and islands of Scotland, in Ireland and, I am sure, in parts of Canada, the fish farm has an additional role -- it provides jobs where they are scarce. We should, therefore, look carefully at our techniques, and train young people, not only to cope with the higher levels of management, stock health and biology, but also to serve as skilled farm workers.

Finally, as farming expands, those developing the industry need to consider how it will fit into their communities, the ecologies, and the physical environments of its site locations. A few farms in a large rural area may merge into the landscape, and not be specially noticed. Dozens of farms present serious problems.

In Scotland, for example, the Scottish Scenic Trust recently pointed out that half of some 300 fish farms in the country are in unspoiled areas hitherto enjoyed by local residents and visitors. Where once existed beautiful scenery, abundant wildlife and tranquility, some $60 million in public money had been spent on fish farming without a plan. Left unchecked, such expansion will be met with increasing resentment and opposition. In many parts of Europe today, fish and shellfish farmers are being urged by their associations and pushed by governments to be good neighbours.

In some cases, this may slow development. But in the long term, it can only benefit aquaculture and ensure it takes and holds its rightful place as a food supplier of increasing importance and as a responsible and caring member of the international fishing industry.

One of the moderators for the Salmonid Sessions was Sandy Campbell, Aquaculture Co-ordinator, Fisheries and Oceans, Moncton. The opening presentations dealt with actual experience(s) to date by several aquaculturists from across Atlantic Canada.

SALMON FARMS IN ATLANTIC CANADA

NAME	AFFILIATION
John L'Aventure	Fundy Aquaculture
Gene Henderson	Salmonid Demonstration and Development Farm
Richard Biggs	Atlantis Sea Farms

THE CASE HISTORY OF AN ATLANTIC SALMON FARM

by

John L'Aventure
Fundy Aquaculture
Grand Manan Island, New Brunswick

We have been in business six and a half years. Below, you see an aerial view of our operation. We started with just a few hundred salmon in 1980, and we've gradually increased to an average of 50,000 smolts, but this figure may vary in either direction by 30 or 40 per cent in any given year.

An aerial view of the Fundy Aquaculture operation.

Dark Harbor is a pond of about 65 acres. There is a channel at one end, and we get half the rise and fall of the tide because the channel is only half the depth of the Bay of Fundy itself. So the bay gets 20-22 foot tides, and we get about 10-12 feet. It gives us a good flush, but it doesn't give us a constant current. But, for protection from wind and wave, there isn't a better site anywhere in the Bay of Fundy that we know of. It's pretty well an ice-free harbor too. We do get some skim ice from fresh water in the winter, but that is not really a problem. So, for an operation like ours, it's a very good location.

When we first entered the business, we never thought about counting fish. We had heard of mysterious loss and disappearance, but thought that with proper control, this wouldn't be a problem. Everybody in the hatchery business in New Brunswick, at the time we started, had been in the habit of weighing their fish and giving a count by sample weight. Even the federal hatcheries used that process. But there were considerable discrepancies in the numbers come harvest time. I think there's only one sure way to find out what you're getting, and that's to do an actual count. What we'd like to see, and what we're trying to do more of, is to count the fish at the hatchery, perhaps a day or two before they're delivered. I don't think that creates undue stress in the fish. They're usually off their feed anyway three days before they're moved and the hatchery people can shift them into separate tanks to be more easily loaded. That way, really, everybody benefits.

Suppose you pay for 10,000 smolts and you only get 6,500 (which is a possibility). If you don't count them until harvest, you may be feeding enough for 10,000 smolts throughout. You may have cages sized for 10,000 and you may have extra staff and everything else. That extra space and extra feed won't make those fish grow much better. They may be marginally better, but they certainly won't grow to the size and the value of the 10,000 smolts you paid for. So the count is extremely important. You'll find later on, when dealing with bankers, that they, too, want to get a handle on the count. What we do now is try to get a count when the fish arrive and again after we've had them a year. We wait until the temperature is warm; and then thin them out. We use a higher density when we first get them because, if you're going to thin them out later, you can utilize your cage space more efficiently.

We've been counting in four grades. The culls (any fish that doesn't look like it's going to make it) we discard when we grade out or empty a cage. Then we have small and large size and grilse. If you wait until the second July, you can generally pick out most of the grilse. This really benefits when you harvest because you can harvest the big ones first, without overhauling the little ones. The little ones will grow better once separated from the big ones, and you can either sell the grilse early, if they're big enough, or wait until the fall or spring. If the numbers from that first accurate count and the second one in the spring tally up when you come to harvest, it gives you and your banker a greater sense of confidence. There's no black box available where you can get the mass or the count, and so I think ours is a procedure that more and more people are going to use.

One of our major costs is feeding, and it's probably the biggest unknown right now. It's also one of the things you put the most labor into. The fish are feeding 365 days a year. At present, we make our own feed because there is none commercially available. I would rather buy everything in a bag with a 100-day shelf-life, but that isn't possible yet.

People continually tell me that making our own feed is probably cheaper than buying it, but we make mistakes. I remember one spring we consistently ran short of fish because there was nothing available throughout the winter. We bought $10,000 worth of herring, only to find that the peroxide count, which is an indicator of rancidity, was double or triple what it should have been -- $10,000 worth of fish to the dump. So much for saving money by making feed yourself! Those incidents do happen.

Right now, we make a moist pellet -- 40 per cent water -- with a one-day shelf-life. The ingredients are quite similar to dry feed, but the moist feed makes better pellets, so the fish eat better. That strategy may change, however. People have suggested that we can go with dry and grow our fish a little longer to sell them over a longer period. We have about 30 per cent of our fish on dry feed now to see how they do, because it certainly would be preferable to use dry feed.

I think feeding styles are also very important. We had two groups of cages on dry feed, and we had a different person in charge of each. We could consistently see whole pellets lying underneath one group of cages. It turned out that one person, when we weren't watching, would dump more feed into the cages than his co-worker, who took more care. That's one of the problems for the industry, to find people willing to work. You must also keep their interest up so they will consistently take care with a monotonous job. We've tried to make one person responsible for each group and to create a little healthy competition among our workers.

Also, the fish should be fed until they're full. If you only partially feed them, or if you hurry it up, different sized fish may get different amounts of feed. The more aggressive fish tend to feed first, and you must make sure the little ones get fed too. Careful attention is required, and feeding throughout the day is important. When we first started, for example, we noticed that fish would eat about 50 per cent of their daily intake an hour before sunset. You have to, therefore, oversee feeding in order not only to benefit the fish, but to get the best production out of them. It makes sense that, if you can feed them beginning at dawn and throughout the day, then, probably, they will use the feed better. Ideally, I would like to have dry feed and install automatic feeders, but I've been told that they should probably be hand-fed throughout the day, so we can see how much they are eating. You just don't get that by simply turning on a switch and leaving them alone.

Lately, predators have come back to haunt some farmers. We've had cormorant problems and other people have had seals. At Fundy Aquaculture, we don't have a seal problem because we're in a closed harbour, but I do recall, about three years ago, that in a two-week period, we lost almost 400 pounds of one or two-pound fish during the winter. They were lost as a result of bites from cormorants. The cormorants can't get into the cages, but they can stick their beaks through and take chunks out of a salmon as it swims by on the perimeter of the net. They won't kill the salmon immediately; it will live for a couple of weeks before becoming very ill or dying.

I know of one grower on another farm who has consistently had fish with lesions on their flanks. For years, he thought it was a Vitamin E deficiency and, just two weeks ago, he finally realized it was seal bites or trauma caused by seals. We had a similar problem about a year and a half ago with lesions and we didn't know the cause either. We sent samples to our fish health people and found out that the lesions were sterile. We also sent some fish to Sterling University in Scotland and their conclusion was the same. They said the lesions were sterile, but were probably caused by trauma. They asked if we had seals, cormorants, or high currents. And that gave me my answer. Cormorants scare the fish which then probably run against their cages. In addition, every fish that has been bitten has probably put the rest of the fish in that cage off their feed, disturbed them, and, perhaps, made them more susceptible to disease. So predator nets are extremely important.

Improvements are occurring here too. Researchers are making a wire mesh predator net, not small mesh, but, instead, big mesh of knitted wire cable. It might keep out both seals and cormorants. They experimented with tight wire mesh a couple of years ago. It kept the seals out, but once fouled, it was difficult to use.

About four years ago, we bought a bird-scaring device. It cost about $200 and was powered by a car battery. The screech was piercing but, within an hour, the gulls were walking beside it and within two hours, the cormorants were standing on top of it!

The problem that was the most frightening and, perhaps, brought us closest to disaster, was lice. In 1980, we had noticed the occasional louse on a fish and this continued until 1984. Of course, two or three lice don't bother a fish, but we topped that. We found up to 100 on each fish, and we don't know what caused the epidemic. When we got up to more than 25 lice per fish, however, we noticed that the fish were jumping against the sides of the net. It was at that point we realized that we had to do something.

We tried several chemical formulations without much success. Then we went through three cages full of fish, combing off the lice. We also tried an acetic acid bath, wiping the lice off with a towel, but it didn't work.

By this time, we had called our insurance company and they put us in touch with Dr. Randolf Richards in Scotland. Within two weeks, we had Nuvon, a product we still use in a dosage of one part per million. It is very simple to use, almost fool-proof, and, in still water, you don't even need a tarpaulin. Most people put a skirt with no bottom around the cage. They lift the fish a little so they are closer to the surface, dilute the drug with a couple of gallons of water, and put it into the tank. In forty minutes, it seems to kill all the lice. It is carcinogenic, however, so we must be very careful when using it. But we have 70 cages; we did them all in two days last fall; and I haven't seen any lice since. We hope we're rid of them for awhile.

Lice have also been called White Spot Disease. They usually stay behind the fins, the anal fin, for example. They don't do much damage there, although they do irritate the fish. But when they move up to the head, because there are no scales there, they can burrow into the skull. The damage that lice can do to a fish is shown in the next photograph. If you can get rid of the lice, however, the fish can recover.

The Effect of White Spot Disease on Salmon.

It takes about 15 minutes to put on the tarpaulin, which is used if there are tides. It then takes 40-50 minutes to kill the lice and another 15-20 minutes for removal. We have found that we can do five or six cages a day.

One final point -- we have never witnessed a drop in oxygen levels because the bottom of the tarpaulin is left open during the whole process. We starve the fish for a day or two beforehand because it's just one more stress and we might as well make it as easy as possible on them.

And there you have the benefit of our experience. I hope you will find it to be of value in your own operation.

DEMONSTRATION SALMON FARMS –
CAGE CULTURE

by

Gene Henderson

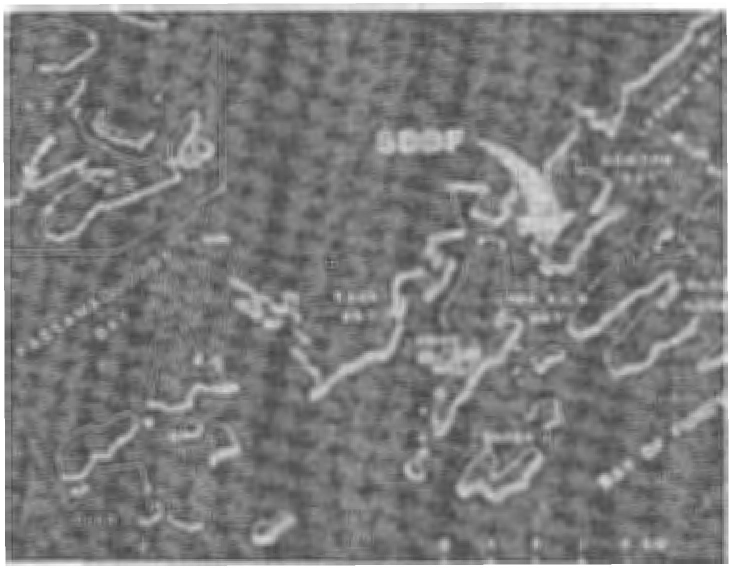
Manager,

Salmonid Demonstration and Development Farm

Lime Kilm Bay, New Brunswick

The Salmon Demonstration Farm is funded by ERDA, (Economic Regional Development Agreement). A proposal was put forward in the summer of 1985 to use some ERDA funds for this farm. That proposal was approved and the funds became available. We felt this is, and will continue to be, a very competitive business. By developing and demonstrating our technologies, we can help commercial farmers become more efficient. That should increase their profits.

The large arrow on the map below shows where the farm is located on the north side of Lime Kilm Bay. This site was chosen because it's central to the salmonid industry in southwest New Brunswick. In Lime Kilm Bay, there are seven farms, and down in Bliss' Harbor, which is on the lower part of the bay, there are, I believe, another five. About 50 per cent of the farms in southwest New Brunswick are in this general area.



On February 17, 1986, I moved out of the Biological Station, rented an office in a cottage on the shore, and began putting the farm together.

The farm has offices, a meeting room (available for industry use), and two labs. We hope, over the next month, to develop nutrition monitoring to replace nutrition studies, and we hope to have the capability, within a few months, to do an approximate analysis, (which involves protein, lipid, ash, moisture and that kind of thing) of the food. Perhaps, some day, another lab will be developed for diagnostic work.

Last year, activity around the shore began to change dramatically from what we had seen over the past six or seven years. This year, the smolts projected to be available to the industry will require something in the order of 300 cages. So there's a lot of activity around the shores of the Bay in the spring of the year now.

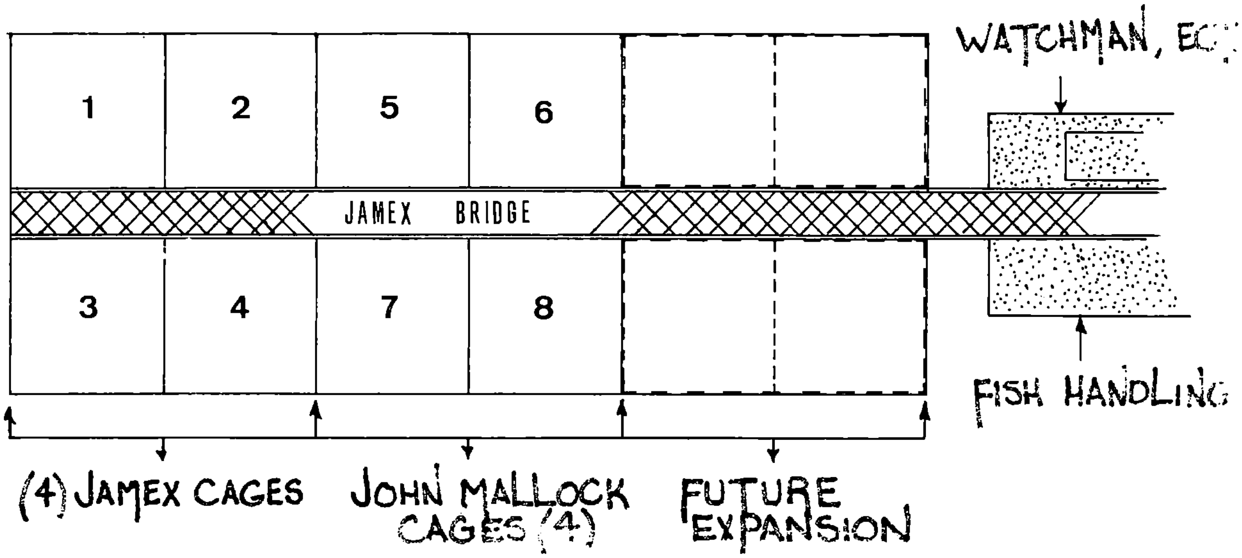
When we were making plans for the farm, we decided to use two styles of cage, a wooden style and a metal Jamex system from Norway. The latter is very expensive, but we thought it might be good for us to bear the cost and demonstrate it to the industry. Until now, farmers have had to speculate on whether they wanted to invest in this kind of system. Now they can see it in operation.

We were not sure, until we tested the system recently, how it would stand up to gales, although we were assured by Jamex representatives that it would. About three weeks ago, we recorded the biggest gale since we put the system out. The seas were, in fact, going right over the rails, which means that they were at least four feet high, and we suffered no damage. So the system seems reasonably seaworthy and will probably stand five or six-foot seas.

Below is an aerial photo of the operation, showing the Jamex wooden octagon cage. We decided to buy extra bridging when we bought the Jamex system, so that we could moor everything along this bridge. It is a wonderful system to work on. Unfortunately, it's very expensive. We worked on it out there all day with no trouble. But, when coming back to shore at four o'clock in the afternoon, we experienced great difficulty with our 20-foot outboards because the sea was so rough.

Figure 1 (below) is the experimental design that we developed as part of our first plan for the farm.

CAGE SYSTEM



Incidentally, we have two committees. One is the Program Development Committee, made up mostly of people involved in research. They give us ideas on suitable projects for the farm and they also act as advisors on how to conduct them. The second committee is the Advisory Committee. It's made up of two representatives each from the province, the federal Government and the industry. So, you see, industry has direct input into the program. After we get ideas from the Development Committee, we put together a program. It, in turn, must be approved by the Advisory Committee. We felt that it was very important that we keep in touch with the industry and that we do things that the industry believes are important.

With the anchor system on the cage site for example, (at the outside where the cold wind comes from), every one of the moorings has a 4,000-lb. and a 2,000-lb. cement block. There are big chains between them and there's one and one-half inch poly-rope. At the top, we use chain again, where we fasten onto the metal bridges. I have been on many cage sites and I have grown lots of fish, but I was surprised at the work and expense necessary to put a mooring mechanism in place to hold such a system in high gales and not have it go ashore. When designing a farm, you cannot underestimate that.

We probably had an overall survival rate with this system of 95 per cent, as compared to 50 to 60 per cent about seven years ago when we had to dip-net fish. When they are being trucked 100 miles, having to use all their osmoregulatory gear, and having to go from freshwater to salt, they can survive only if they are truly good smolts. But if, in addition, you have to handle them and dip-net them, you're certain to have some mortality.

We run our farm as much like a commercial operation as we can, using commercial cages and commercial techniques. We use the same kinds of nets and feeds, but, other than that, the similarity ends. Probably one of the main differences between this farm and another is that we collect a lot more data; they're busy growing their fish and don't have the time to do this. We, therefore, have much more information at the end of a cycle, perhaps, than would a commercial farm.

The following is some of the information we have collected on the farm during the first year. Our last measurement was taken Dec. 2. Smolt age groups that we use are 1+ and 2+ smolts. It is important that we look at these two groups separately and check their performance to see if we can determine whether one was better. The second consideration is the type of feed used. We have dry commercial feed and moist commercial feed. The third factor we looked at was density. Most commercial farmers in the Bay of Fundy now are putting about 2,500 fish in a cage and going straight to market with that group of fish. We wanted to know if we could put in 5,000 fish during the first summer and then divide them in the fall or the spring, and whether that would affect the growth and survival rates. In the spring, this would reduce the number of cages required, although eventually the same number would be required in order to split the smolts up sometime later. Some farmers have difficulty getting enough cages built in February and March to hold all the smolts they have coming on. If our plan works, they will have the option of building some of those cages during the summer.

Table I depicts conversion results of two types of food under the conditions just described.

Table I

Food Conversion

Date	2+Moist	2+Dry	1+Moist	1+Dry	1+Moist(5000)
May-Sept.8	1.58	1.23	1.55	1.17	1.52
Sept.-Dec.2	1.96	1.64	1.87	1.50	1.82

If we look at all the groups on moist feed, we find that they're quite similar from May to September. If we look at the dry data, they are different, but probably not significantly so. If we look at the data from Sept. 9 - Dec. 2, we see that the conversions have dropped a bit. The only explanation I have for that is, as we get into the fall season, we have wind and waves to contend with. The fish drop deeper in the cages and they're harder to see. I suspect that, rather than any change in the fish or the feed, it is probably our inability to tell when the fish have stopped feeding that causes the problem. We're probably wasting a little feed that we do not waste when the fish are up high in the summer and eating very actively. When we come to the effect of density, the difference is very modest and perhaps not significant. Until the end of October, it doesn't really matter whether you had 5,000 or 2,500 fish in the cage. The growth and survival rates were about the same.

In looking at the growth rates of the various groups (Table II), you notice two things. One is that the fish on the moist feed, is they are of a similar age to those on dry feed (i.e. 2+ on the moist and 2+ on the dry) have growth rates which are very similar early in the year; but those on moist feed achieve higher growth rates as the year progresses. The other interesting thing is that the 1+ smolts, although they're smaller when they start and are still smaller at the end, are always growing at a slightly higher rate. I don't believe that's going to result in them catching up to the two-year-old smolts, but they do grow slightly faster. However, we will have to wait until we go through the whole cycle to see what happens in this regard.

Table II

Growth Rates (Percent per day)

Date	2+Moist	2+Dry	1+Moist	1+Dry	1+Moist
May-July 8	0.97	1.01	1.33	1.48	1.34
July 9-Sept.8	1.80	1.71	2.07	1.92	1.97
Sept.9-Dec.2	1.09	0.88	1.25	0.96	1.21

Below, I've plotted the food consumption of the the 1+ smolts (Figure 2). As I mentioned earlier, the density effect only developed about the end of September and so, throughout a major part of the year, we achieved the same level of performance and feed consumption with 5,000 fish or, in other words, double the density normally used. The other point is that the reason we reached the higher growth rates (Table II) was that the fish ate much more of the moist feed. Thus, some of the difference may be a result of the different amount of energy in the diets.

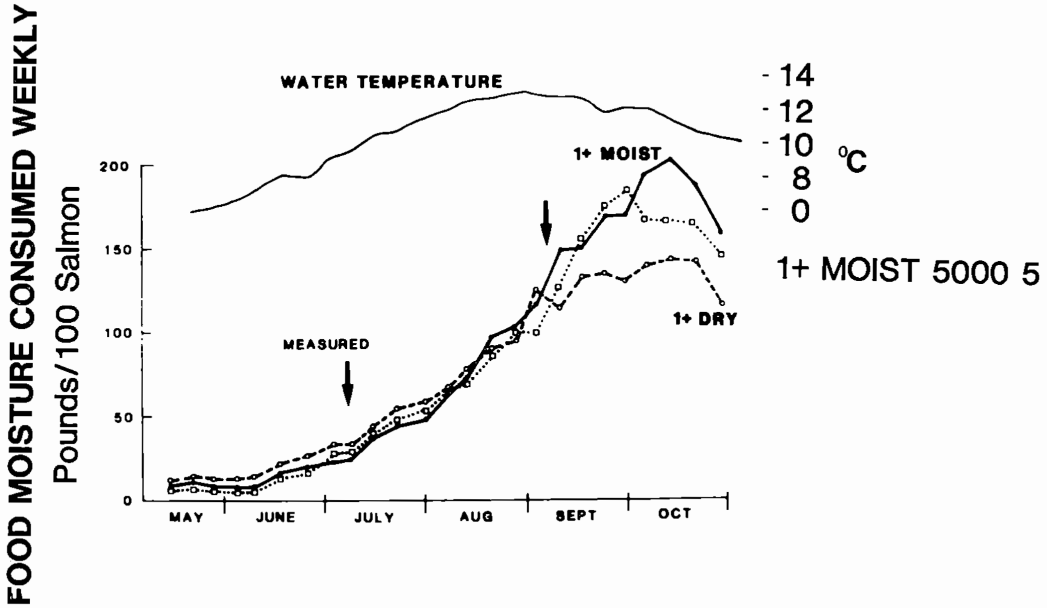


Figure 2. Food Consumption of 1+ Smolts, Moist vs. Dry Food

The moist feed registers approximately 37 per cent moisture and the dry feed has approximately 8 to 10 per cent. If this moisture is removed, how much feed, on a dry-weight basis, is the fish eating? Although the amount of moist feed is reduced, it translates into about 50 lb. per day on a dry-weight basis, so it seems to be a palatability factor. The fish really like the moist feed, and they eat great quantities of it, compared with the dry.

The two-year-old smolts also show a dramatic difference, eating twice as much of the moist feed as the dry.

So, although I think probably both diets can be and have been improved, so far we don't have a dry feed that the fish will eat in the same quantities as they will the moist. Even if the feeds are equal in calories and energy, unless you can get the fish to eat it, you're not going to get the same growth rates.

We're also doing a lot of environmental monitoring. There's been some concern about pollution build-up and that sort of thing. Aside from that, we're looking at anti-foulants on nets, monitoring oxygen levels in the cages daily, and collecting data, other than fish data. Work continues.

DEMONSTRATION SALMON FARMS –
LAND-BASED CULTURE

by
Richard Biggs
Atlantis Sea Farms
Clifton Royal
Kings County, New Brunswick

The Atlantis Sea Farm is a trout and salmon growout facility located on the shores of the Kennebecasis Basin in Kings County, New Brunswick. It has been operating at this site for about 10 years, but has been using Basin water for only the past four years.

The farm is located on the Kennebecasis Basin to take advantage of unique conditions – two separate water layers:

1. a fresh surface layer, which undergoes normal seasonal temperature variations from a high in summer of 21°C to a low in winter of 0°C, and;

2. a lower layer which is primarily seawater. This layer has some unusual characteristics. During winter, the temperature normally runs between 6 and 10°C. It has a summer temperature of between 2 and 3°C. These two layers in combination create growing temperatures that normally range from 16°C in summer to 6°C in winter.

There are two hatcheries, two pumping stations, and 11 shore-based tanks. All water is supplied by the two pumping stations. They can supply 2,400 gal./min. and we are doubling that to 5,000 gal./min. this year.

The most common impression of pump-operated facilities is that the electrical costs are prohibitive. This does not, however, seem to be true at our location. The shore facilities consume about $600 a month in electricity -- one of the smallest operating costs.

The growing tanks are three different sizes. We have four 50-foot circular tanks capable of operating at depths of up to six feet. These are our main growing tanks. Each is capable of producing 25,000 lb. of salmon smolts, 18,000 lb. of market size salmon or 35,000 lb. of marketable trout. The remaining tanks on site are three 27-foot circular tanks and four 18-foot circular tanks. These have a normal operating depth of between two and three feet. They are used to produce the fingerlings to be grown out in the 50-foot tanks. All of the circular tanks on site are constructed of galvanized steel walls with 40 ml. plastic liners. We have found this to be the most cost-effective form of construction. In recent years, it has been suggested, liners may release toxic substances. However, we have had no losses which could be attributed to that.

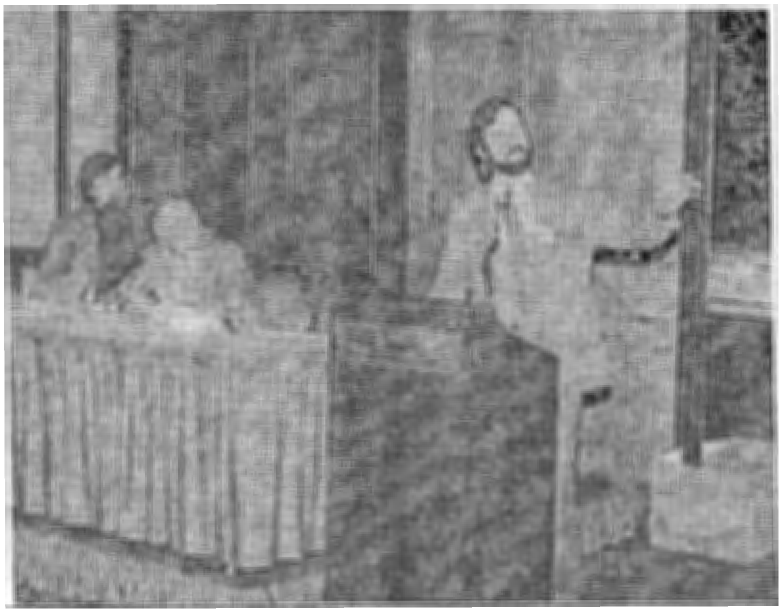
Shore-based growout offers a great many advantages in fish management. We have experienced, on average, feed conversion of around 1.5 lb. of feed to 1 lb. of fish. Because the fish are readily visible at all times, waste feed is kept to a minimum. At present, all fish are hand-fed, but we are converting to demand feeders. The nature of the tanks also makes counting inventory or grading rapid and easy at any time of the year.

The ease of fish handling allows us to grade off of a specific size of product. We can quickly grade off, say, 5-lb. fish as they develop, while the remainder can be allowed to continue growing until they reach the desired size.

The most essential factors in a facility of this type are reliability and fish health. Due to our dependence on a continuous supply of water, we have a system of safeguards. Three pumps provide water so that the failure of a single pump will cut the flow by no more than 30 per cent. In addition, a replacement pump is kept on hand. To protect against power failure, a diesel generator is also on site and checked weekly. Water is distributed through two independent pipe systems.

Fish disease can be one of the greatest dangers in a shore-based growout facility. We have learned this the hard way. About four years ago, we had a severe outbreak of furunculosis. The trout became carriers and losses were minor, but we lost about 50 per cent of our salmon to the infection. New vaccines and drugs have since allowed us to control the problem, and there has been no sign of this disease in the past year.

The intake and distribution lines of a shore-based salt water system like ours are normally fouled with marine life. A similar system in Otterferry, Scotland must be cleaned every three to four months. At our operation, due to the nature of the salt water there, we have experienced only minor fouling after four years and are considering cleaning the system this year for the first time.



John L'Aventure of Fundy Aquaculture, Grand Manan Island, New Brunswick, discusses his experiences as a producer while moderator, Sandy Campbell; Peter Hjul, Editorial Director, _Fish Farming International_; and an attentive audience looks on.

SEED STOCK SUPPLY IN NEW BRUNSWICK AND NOVA SCOTIA

by

David J. Scarratt
Department of Fisheries and Oceans
Halifax, Nova Scotia

From the beginning, federal policy on salmon farming has been to encourage the development of private suppliers, while, at the same time, making allocations available from federal hatcheries to meet any shortfall. Fisheries and Oceans (DFO) has increased its smolt supply to 50,000 in Nova Scotia and 150,000 in New Brunswick, but will only release these fish if all private supplies are bought up by growers, or otherwise planted out.

In 1982, projected demand over the subsequent five years indicated development would take two different courses in New Brunswick and Nova Scotia, as shown in Table I.

In Nova Scotia there was a clear suggestion that the industry would become vertically integrated, thus meeting more of the demand. In New Brunswick, it appeared there would be a widening gap between supply and demand.

Table I

PROJECTED SMOLT DEMAND - JUNE 1982

Year	Nova Scotia	New Brunswick
1983	47	202
1984	78	295
1985	73	443
1986	18	398
1987	6	406

Note that demand is difficult to define and can rapidly inflate. There is no clear relationship between the industry's demand and its capacity to raise fish.

In any event, the evolution of the industry in the two provinces has been different, and different from what was projected.

In New Brunswick (Table II), there has been a number of sources, varying from year to year, on which the industry has relied. The federal allocation grew to 150,000 in 1986, while its share of the total supply has dropped from more than 80 per cent in 1983 to a projected 15 per cent in 1987, at which time the bulk of supplies will be from the private sector.

Table II

SMOLT SUPPLY AND DEMAND (in thousands) IN NEW BRUNSWICK

Demand			Supply		
Year	Projected	Actual	Private	Federal	Shortfall
1983	202	200	15	73+	112
1984	295	300	56(51)*	54(24)*	190
1985	443	2	?	125	?
1986	398	615	400	150	~65
1987	406	1000	750	150	~100

* Allocated - but not delivered

? Figures not readily available

In 1984 (Table III), there was a major interruption in supply due to furunculosis outbreaks at Grand Lake Resources and at Mactaquac. The supply was finally secured from a variety of private, federal and experimental sources. The outbreaks stimulated a program of carrier testing in which fish were screened to ensure the disease was not transferred to farms.

Table III

SOURCES OF SMOLT IN NEW BRUNSWICK IN 1984

Sources	Number
G.L.R.	(51)*
Mactaquac F.C.S.	(24)*
Saint John F.C.S.	54
Strangs	8.6
St. Andrews	12.3
A.S.F.	26.1
Marine Products	9.0
	110(75)

*Furunculosis infected, therefore, not delivered

A similar type of program is in place at two farms where clinical outbreaks of Bacterial Kidney Disease (BKD) have occurred. Here, reproductive specimens from brood fish are examined to ensure BKD is not transferred to the hatcheries. As egg supply increases, there will be increasing pressure to reject eggs from infected sites. Hence, the need for good husbandry at the farms and, perhaps, a disease eradication program. There will be similar pressure to reject eggs of indifferent parentage.

In Nova Scotia, (Table IV) demand has escalated relatively slowly and, for the most part, has been matched by supply. Most growers appear to be reasonably satisfied.

Table IV

SMOLT SUPPLY AND DEMAND (thousands) IN NOVA SCOTIA

Demand			Supply		
	Projected	Actual	Private	Federal	Shortfall
1983	47	?	?	?	?
1984	78	?	?	26.2	?
1985	73	70	50	20	0
1986	18	115	65	50	0
1987	6	135	100	50	(15)

? Figures not readily availble.

Note that zero shortfall does not mean that surplus smolts would not have been sold. Demand in this case may simply have reflected known supply.

There is, however, a serious shortfall developing in supply, if planned major projects proceed. Demand for fry (Table V) in 1987 for smolt production in 1988 and 1989 is 1 million. Supply, however, seems unlikely to exceed 350,000. This may be a serious constraint to meeting business projections.

Table V

FRY DEMAND AND SUPPLY FOR 1987 IN NOVA SCOTIA

	Demand		**Supply**	
	Actual	Private	Federal	Shortfall
1987	1000	150	200	650

The points that emerge are:

1) In a developing industry it is essential to maintain as large a number of suppliers as possible, since not all will be able to deliver;

2) It is essential to ensure that smolt producers and salmon growers develop programs of mutual support. Neither can expect the other to produce smolts or eggs out of thin air;

3) It is essential to develop a program of disease testing and control to ensure that diseases are not transmitted between hatcheries and cage sites or vice-versa.

The federal government does not intend to compete with the smolt-producing industry nor to continue producing smolts for the growers indefinitely. It is our intent, however, to continue to provide access to wild stocks for purposes of brood stock development and conservation, and appropriate policy will be developed to that end.

SALMONID CULTURE IN EUROPE

by
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Editor
Fish Farming International
London, England

Salmon culture is an aspect of fish farming that has really caught the headlines in the last 10 years or so. There have been many exaggerated statements about it, and I think there are other aspects of fish farming which, probably, in the long run, are going to be equally important. But, at the moment, it is salmon production which is making the money and, more particularly, it is salmon production which is advancing the whole concept of aquaculture, speeding up its technological and marketing development.

The front runner, as Mr. Niles pointed out, is Norway. The Norwegians will venture into things that many people would not and that is one of the reasons salmon farming has been a runaway success there. The Norwegian industry traces back to the mid to late 1960's, although even before that, a great deal had already been learned about salmon the hard way. The Norwegians learned from the Canadians, the Americans and the Japanese, all of whom had been working on salmon enhancement and salmon hatcheries for many years, during which time a lot of mistakes had been made and, subsequently, corrected. The Norwegians, therefore, had something to go on. They had their own innate knowledge of fish; they had this desire to use their fiords; and they wanted to produce good salmon.

They gained experience with sea-growing trout and then began to work on salmon, at which point they went in two directions. The first was the big farm, which was was also being tried in Scotland at the time by the Unilever Organization. In Norway, a firm called Movay began developing in this way, and a man called Thor Morvincal, whose name should be written into the history of salmon farming, developed a fiord enclosure-type operation.

Movay, today, is the only salmon farm in Norway that remains a large-scale operation. It produces about 1,000 tonnes a year and, after the Unilever operation in Scotland, is the largest fish farming operation in Europe. It's still very successful. It's part of the north Kedrahedro group. Thor Morvincal has since sold his interest and is active in other aspects of salmon farming. But he's still a leading figure in the industry in Norway.

From this kind of beginning, the industry then began to move to small-scale operation. These pioneers found they could grow salmon as well as trout in sea cages. So the sea cage idea is the other significant development to emerge from Norway.

The first great hurdle that sea-cage operators had to overcome was finding a supply of smolts. Hatcheries became an urgent necessity for Norway. At the moment, it's a sellers' market in smolts, resulting in two unfortunate effects: 1) if someone in Norway gets permission to start up, he can never do so on the scale he would like because he is limited in the smolt he can buy but, worse than that, 2) this situation tends to reduce the quality of the smolt that are available. This remains a major problem in Norway.

In the Fish Farmers' Sales Organization, there are two tandem organizations, and one of their prime objectives at the moment is to develop a selective breeding program. They want to change salmon from a wild fish to a very good, domestic species, a healthy fish from good breeding stock. So their breeding station, which has just opened near Tromso, is involved in a very complex program which will mature, I think, about 1994 or 1995, and will produce much better salmon stocks. To produce better salmon through a selective breeding program is something I think anyone in aquaculture should be looking to, as we start from a very small base and build heavily upon it.

The growth of Norwegian aquaculture has been confined until now, almost entirely, to small-scale farming. In addition, there are about 2,000 applicants waiting for licence approval at the moment and licences have been granted at a rate of only 100-150 per year. A licence is given for 8,000 cu.m capacity, which is generally 8-15 cages (small cage size). The farmer seldom starts with anything larger than 4,000-5,000 cu.m. He gets a bank loan at the normal rate of interest. He gets very little government support. But once he gets his licence, it's his licence to go to the bank. The bank will carry a farmer for about 500,000 to 600,000 pounds, and the farmer will go for three years without seeing any return on his capital. He gets his licence around August. He then sets up his farm, puts in his cages and his computers, and gets his first smolt the following May. The smolt boat delivers them to him and he then has to wait two years before he can harvest that crop. So, in all, he has three years to wait, and that is how it generally goes in Norway.

Norway has something like 700 farms and hatcheries, although hatcheries are separate from farms. Hatchery licensing is far less restrictive than farm licensing or ongrowing licensing. The Norwegians have approximately 200 hatcheries or maybe more. They are restricted to about 500,000 smolts a year, plus a certain number of trout. Only recently, have they allowed some of these hatcheries to go up to a million smolts. But they're beginning to wonder if they were wise, because smolt production is now probably going to outstrip production capacity and there may be a surplus of smolts.

I think we should also remember that not only Norway is producing salmon. Some of the more interesting and exciting developments in salmon culture in Europe are taking place outside Norway. In Scotland, for example, there was a different pattern of development. The great pioneer there was the Unilever Organization through Marine Harbours, which has a chain of fish farms today and has set a very good research and development pace all the way through. Great credit goes to it because it has really put fish farming on a good healthy footing in Scotland. Other big corporations have come in, such as Booker McConnell, which also has large, flourishing salmon farms. But the really interesting development in salmon farming in Scotland is the small-scale operation. Scotland is now dotted with ex-civil servants making more money than they ever made before in their lives; they're doing very well indeed in fish farming.

The locations of this development are also interesting. The Western Isles is one such area. A man called Collin MacDonald recently set off for the Hebrides, for example, and he and a number of colleagues have set up small farms linked to hatcheries which they also operate themselves. There are probably 60 or 70 such farms in the Hebrides today and this represents a very rapid development in aquaculture. They are crofter-style operations, small farms growing between 50 to 70 tonnes of fish, producing very good quality, and setting up their own co-operative marketing operations.

This phenomenon has spread North to the Shetlands, where there are now about 45 farms. Every two years in London, there is an International Food Exhibition; there was one last week. One of the highlights of the exhibition was the quality of the salmon on show, and this salmon all came from Scotland. In one of the stands, there was a sample on display and people were stopping and asking where it had been caught. They were told it had been grown, proving that it is not true that wild salmon is better than the farmed salmon. People can't tell the difference. There was a taste test in London recently involving Scottish wild salmon and Scottish farmed salmon. The only people who knew the difference were the connoisseurs or gourmets. Farmed salmon is neither better nor worse than wild salmon, and most people cannot tell the difference.

Scotland has something like 150 or 160 farms. I expect last year's Scottish production of farmed salmon to amount to about 9,000 tonnes.

Ireland is also an exciting area for salmon production. However, Ireland, unlike Scotland and Norway, has very few sheltered areas in which to farm fish, so it is looking to land-based farming. It has not, however, succeeded as well as sea-cage farming. It's been tried in several parts of Scotland and in Iceland. They are growing salmon in cages, but they are using the big Bridgestone or Kames cages -- cages that hold something like 50 tonnes of fish. They are used in Japan for growing Yellowtail. Japan grows about 150,000 tonnes of Yellowtail a year in fairly exposed sites using these very large, strong cages.

Ireland has developed what I think is one of the best and most comprehensive reports on the European salmon industry. It has now been published and is available from the Irish Sea Fisheries Industries Board for about $250. If you really want a comprehensive overview of salmon farming in Europe, that's the review to get.

Now we go to another area which is probably going to be one of the most important salmon producing areas in Europe, the Faeroe Islands. The Faeroe people are like the Norwegians, hardy, resourceful fishing people. Fish is their main industry, and they looked fairly early on towards salmon. Their problem, like Ireland's, is a lack of sheltered sites. They do have a number of fiords, of course, but they're very exposed. So they, too, have had to look to big cages, mostly to the Bridgestone cage, which seems to be a successful product.

The last country in Europe which is really going ahead with farming is Iceland. Iceland has a variety of different conditions. It has ideal conditions ashore. It has warm-water springs. Icelanders can produce salmon smolts under ideal warm-water conditions to grow very rapidly. But when they put them in the water, they have a problem because they've got a growing period from only May to November, and, then, it's far too cold to keep the salmon in the sea. So they tend to grow large smolt very quickly, putting them in cages and hatching them out about November. This means a very short cage time for ongrowing. It may not produce ideal fish, but it may produce an acceptable one for the changing European market.

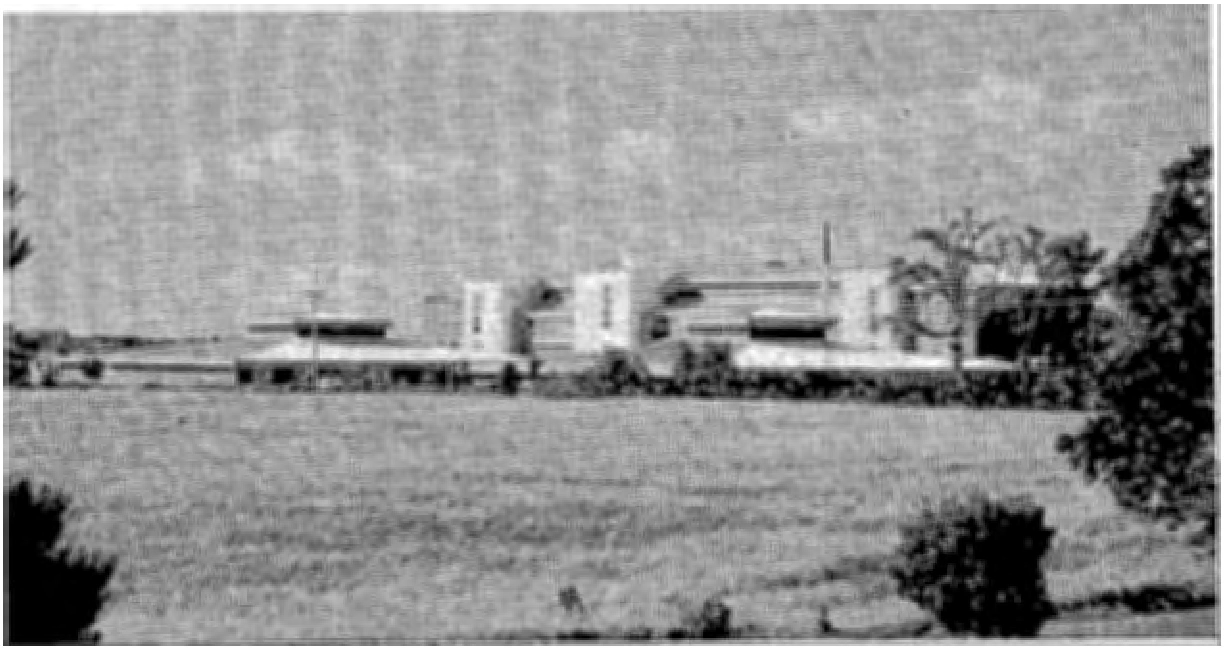
There are other possibilities in Europe. Sweden has hatched fish for many years and put them into the Baltic. In Finland, they've not really grown salmon. They do grow sea trout there, out around the islands. Incidentally, one of the interesting things they do is hold their trout in the water throughout the winter. One major producer harvests them in March by breaking the ice and pulling the fish out. He's been quite successful.

So, this is the pattern in Europe. Norway is taking the lead. But a lot of interesting work is going on in other countries.

I have heard that, in this part of the world, there's been some resentment of Norwegian involvement and investment. I must point out that this is not the case in Scotland where the Norwegians have been generally welcomed. There, the Norwegians have made a large and important contribution to the development of aquaculture. They have brought in capital when our own people weren't prepared to invest. But the Irish have tended to share the Canadian view. They rather resent the bigger Norwegian presence. The Norwegians are also heavily involved in Iceland. But, generally speaking, the Norwegians are not as strongly opposed in Europe as they are in Canada.

We have now reached the stage in salmon farming in Europe where the technology exists to do the job. However, one of the things we still have to do in aquaculture, as we get more technical and sophisticated, is to look more to training. We have to train people in aquaculture. At the moment, each worker on a Norwegian salmon farm produces about 14 tonnes of fish a year. Each worker on a Scottish farm produces about 11 tonnes a year. The feeling is that this production level could rise. That's going to require highly trained people, not necessarily people with a biology degree, but people who are trained as good technicians and husbandrymen. Thankfully, at the moment, there are colleges setting up in Europe to do that.

The final and the biggest problem we have now is marketing. The Norwegians got their marketing act together right from the beginning. The Scots are getting theirs together very well. The Irish have always had good marketing support for their products, and so, of course, have the Icelanders, and the Faeroese. So all of these producers are hitting the market with a product. During the past year, there were 56,000 tonnes of salmon in total on the market, and a lot of that came on during the last couple of months. Around Billingsgate, a week ago, you couldn't move for Norwegian fish boxes and, if buyers took a couple of tonnes of salmon, they were getting it as low as $1.70 a pound, right around the cost of production. That is the biggest worry. But I'm not distressed about the marketing problem. It is a problem, and there is a surplus, but we have a fish that is really saleable. The technology is there to develop it. And I think the industry has a tremendous future.



Atlantic Veterinary College

University of Prince Edward Island

THE ATLANTIC VETERINARY COLLEGE AND AQUACULTURE

by

Dr. R.G. Thompson
Dean of the Atlantic Veterinary College
Charlottetown, Prince Edward Island

The Atlantic Veterinary College will be a significant resource to the Atlantic region and will contribute significantly to the aquaculture industry. I will briefly convey the general resources available.

There are four academic departments:

1. **Anatomy and Physiology**, which has faculty in the disciplines of anatomy, histology, physiology, pharmacology, toxicology, animal behaviour, animal welfare, and nutrition;

2. **Pathology and Microbiology**, with the disciplines of pathology, clinical pathology, bacteriology, virology, immunology, parasitology, public health, avian diseases, wildlife diseases, fur-bearing animal diseases and laboratory animal diseases;

3. **Companion Animals**, with the disciplines of medicine, surgery, radiology and anaesthesiology;

4. **Health Management**, with the disciplines of medicine, surgery, reproduction, epidemiology, statistics, animal science and animal production systems.

There will be about 60 faculty and 110 staff when the college is fully functioning.

The major activities of the College will be teaching, research, service and continuing education involving many species of animals. A M.Sc. degree is in place and students are now registered. A Ph.D. program is planned, possibly with a link to a major university nearby.

The major functional areas of the College are as follows:

Classrooms; research laboratories; teaching animal areas; the veterinary teaching hospital, which includes farm animals and companion animals; research animal areas, including isolation facilities; diagnostic laboratories including pathology, bacteriology, virology, parasitology, immunology, toxicology, clinical pathology, electron microscopy, radioisotopes, pharmacy and medical records.

The fish health area is a space dedicated for tank rooms, isolation rooms and food preparation. It is located next to the diagnostic laboratories and very close to the post mortem room, which also has an area dedicated to fish pathology.

The building contains about 145,483 net square feet. The federal Government paid half the capital costs, and the four Atlantic provinces paid the remainder. Operating costs are shared by the Atlantic provinces.

The fish disease area now has a pathologist, a plant manager and a technologist. Further staff will be recruited. Dr. Gerald Johnson is a veterinary pathologist in charge of the fish health area. He has made many contacts with persons involved in aquaculture in the region and particularly with the Department of Fisheries and Oceans. There appears to be a very good climate for mutually beneficial interaction between the Atlantic Veterinary College and the many groups involved in the region's aquaculture industry.

FISH HEALTH AND DISEASE CONTROL

by

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INTRODUCTION

Fish health, in its broadest aspects, involves the well-being of all fishes as we know them, and includes such things as good nutrition, good physiology and also the presence or absence of any infectious diseases. It has been estimated infectious diseases are responsible for up to 80 per cent of the losses in any given culture facility.

Three diseases are a concern for finfish culturing -- fresh and saltwater -- in Atlantic Canada. They are vibriosis, furunculosis and bacterial kidney disease (BKD). The latter two are causing us the most concern. I've included vibriosis only because it has a heavy impact on the marine environment, but currently seems to be under control.

VIBRIOSIS

The causative agent of vibriosis is Vibrio ordali in salmon and Vibrio anguillarum in rainbow trout. It is transmitted from infected feces in the water. The symptoms of the disease are open lesions on the side of the fish; there is erosion of the dermis, freeing up the underlying muscle. This is primarily a saltwater disease, so everything I say about vibriosis deals with a saltwater cage operation.

The organism affects both rainbow trout and salmon in cage culture, and is present in all Maritime provinces. It is being held in check through the use of vaccines and also through chemotherapy. Without treatment, fish eventually die through toxins produced by the organism. Also, with open tissue, there will be considerable water loss and ion inbalance in the fish.

Vaccines are quite effective in controlling the disease and we now have, on the market, both dip and injectable versions. We also have antibiotics such as oxytetracycline, which seems to do a very effective job. We don't see much vibriosis these days. But when I was first involved in this business, 10 years ago, people raised a lot of rainbow trout and the disease was a real problem.

When you're treating with antibiotics there is always the possibility of resistance developing. Very early in treatment, we witness the appearance of antibiotic resistance strains of Vibrio occurring, which means, in many cases, that we have to move from one antibiotic to another.

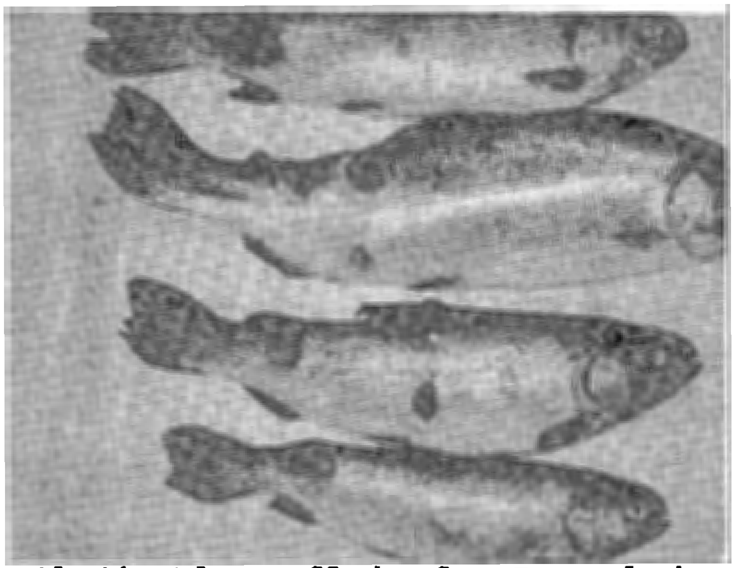
People tend to think you can use antibiotics at very low levels on a continually in order to control disease. This is probably the worst thing you can do. You should use the recommended dose for the prescribed period of time. If you do that, you should have no trouble with resistance developing to the antibiotic.

FURUNCULOSIS

Furunculosis is a real problem in both fresh and saltwater situations. Currently, in Atlantic Canada, furunculosis is present only in New Brunswick, where it is endemic on the Restigouche and Saint John River systems in both cultured and wild stock. The fact that it is only found in New Brunswick is probably due, in large part, to the Fish Health Regulations in effect in the region which prohibit movement of live fish from one province to another, unless they can be shown to be free of certain diseases.

Furunculosis is now a real problem in salmon, especially in salmon smolts. It can be treated with antibiotics such as oxolinic acid and Romet-30. In addition, for the first time, we have a vaccine available through Aqua Health Ltd. in Prince Edward Island, which protects fish against this. The vaccine, as I understand it, is available in injectable or dip form. Last year for the first time, smolts going into seacages in New Brunswick were injected or dipped with this vaccine. At this time, we're still awaiting the results.

The cause of this disease is _Aeromonas salmonicida_, a small, rod-shaped organism. The photograph below shows a fairly large Atlantic salmon suffering from furunculosis. The symptoms include boil-like lesions at the skin surface and, if you cut into these lesions, you find a very necrotic tissue underneath the skin surface.



Atlantic Salmon suffering from Furunculosis

One of the problems in treating this disease, as with vibriosis, is the emergence of resistant strains. Very early on, when we were treating this disease with oxytetracycline, we saw these strains emerge. So we've moved from oxytetracycline to oxolinic acid, which appears to be more effective. This drug is available in New Brunswick through the veterinary service at St. Stephen. However, none of these drugs is registered for use in fish operations. They are only available through prescription and, in some cases, there are even further restrictions. Some can be used only in an emergency. A veterinarian is not free to prescribe them until he has contacted Ottawa and gotten permission for an emergency drug release. Usually such drugs have not been extensively used here and they're still being used on a trial basis.

The prognosis for this disease is good. A big problem with furunculosis in freshwater is the fact that fish can become carriers without us detecting the organism in their tissues. We have a program that looks at all fish moved from one watershed to another within a province. Samples are submitted when such a move is planned. The fish are examined in our laboratory and if bacterial kidney disease, furunculosis or enteric redmouth are detected, they are not permitted to be moved to another watershed unless the diseases are also present.

Early on, we found some of these diseases had passed unnoticed through our screening procedures, and it became obvious that we had a carrier situation developing in smolts, which was not detected by our culturing methods. The only method of detection is through the use of an immuno-suppressive test. We put fish into a holding area, inject them with an immuno-suppressant and bring down an active case of the infection. In this way, we are able to screen them. We put the carrier testing program in place to make sure that furunculosis from the freshwater sites would not show up in the marine cages.

We have had a program for a number of years now in which all rainbow trout or smolts going into saltwater cages are carrier-tested. We carry this out in conjunction with the New Brunswick Department of Fisheries. In the past we have detected carrier situations and, although in 1985 some of these carrier fish slipped through our screening procedure, last year we prevented this for the first time. There were no outbreaks of clinical furunculosis in any of our cage sites.

BACTERIAL KIDNEY DISEASE (BKD)

This disease is, without a doubt, the most important emerging disease in the area. It is insidious. There is absolutely no treatment, so far as we know. There are no effective vaccines and there are no drugs to combat it. The drug that is available, erythromycin phosphate, is only marginally useful; the problem is that the organism is tied up in the tissues and not readily accessible to the drug. Affected organs display swelling and begin to malfunction. The disease can affect the spleen, kidney, and liver. It appears on the organs as whitish pustules. What sets BKD apart from other bacterial diseases is that it is the only one we know of that is vertically transmitted in the egg. We understand that viral diseases are vertically transmitted, but this is bacterial. Other bacterial diseases are effectively controlled through disinfection of the eggs (because any transmission would take place on the outside surface of the egg). It has now been demonstrated without a shadow of a doubt however, that this organism is transmitted inside the egg, remote from any treatment you might want to apply. So the disease can be transmitted undetected and uncontrolled from broodstock to offspring.

We have been using erythromycin phosphate. This can be effective if you treat the broodstock several months before you're going to strip the fish. We do not recommend that people buy eggs from suppliers who have fish that have a known history of BKD.

A number of years ago, when eggs were in very short supply, it became necessary to institute a program to minimize the risk that people would use infected eggs. In collaboration with people on the west coast, we developed a technique in which the broodstock would be injected with erythromycin phosphate several months beforehand. This would knock back any active infection, and we would then screen the eggs by looking at the reproductive fluid of the broodstock, using sensitive flourescent techniques. The eggs would be held in quarantine. We would do the tests and if any fish were shown to be positive, we would reject their eggs. It appears, given the results of this program over the last couple of years, that it has been effective in dealing with BKD in a clinical situation. I'm afraid, though, that elements of the industry have become somewhat complacent about the program.

We're going to have to wait and see if any vaccines will be developed to control BKD. Vaccines are going to be our salvation with respect to disease control in the fishery. Certainly, with furunculosis, we see them as a long-term solution.

Figure 1 shows some of the components of disease control. Two important aspects are regulation and fish health management practices. Regulatory control, a government function, seeks to impact the spread of disease via the movement of infected fish. The National Fish Health Protection Regulations, Regional Fish Health Policies (controlling disease transmission between watersheds within a province), and specific disease control programs are included. These programs are administered by DFO out of the Fish Health Service Unit in Halifax. But fish health management is the responsibility of the culturist, and involves both prevention and treatment. Prevention includes various aspects of stock selection and cultural management practices, while treatment involves consideration of such elements as diagnosis, therapy, withdrawal, antibiotic resistance and stock destruction.

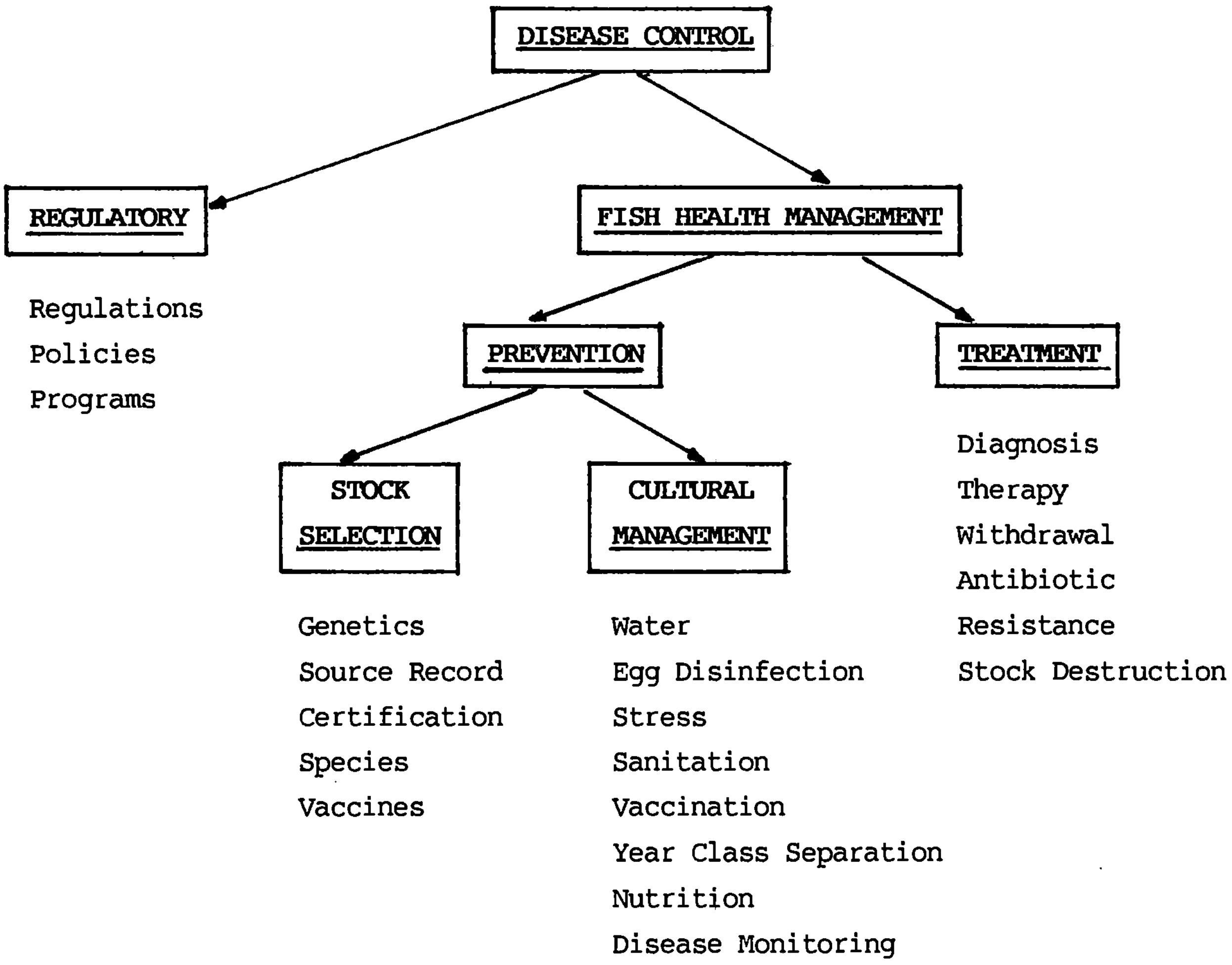


Figure 1. Aspects of disease control in the Atlantic provinces.

WATER QUALITY

by

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Advanced Lobster Technology Inc.
Victoria, Prince Edward Island

One of the problems the expanding aquaculture industry faces in Atlantic Canada is the limited availability of suitable sites, both for fresh and seawater installations. Many areas have already been designated by government as recreational and, therefore, not available for aquacultural purposes. The major factor limiting the availability of sites, however, is water pollution. Many of our streams, rivers, and lakes have experienced dramatic reductions in pH due to industrial pollutants. Dumping toxic industrial wastes and untreated sewage has rendered some bodies of water incapable of supporting fish safe for human consumption. Another source of pollution to surface water is runoff containing insecticides and fertilizers. Action is being taken to minimize and control pollution, but, as long as there are other industries, pollution will be present.

Wide seasonal temperature fluctuations and harsh winter weather conditions impose restrictions on aquaculture in Atlantic Canada. One result is the seasonal marketing of products, rather than supplying the marketplace throughout the year.

As the aquaculture industry grows, more sites will become land-based. As sources of quality water become more limited, there will be a move toward reusing water in contained, land-based installations. This is already being done in parts of Europe. This requires more capital than natural-based installations, however, because equipment is needed to purify the water. Operating costs are higher, too, because of the increased demand for electricity. On the other hand, waste products from the fish can be collected and used as plant food, reducing a potential pollution problem that would be created by dumping them into a stream, river or ocean. If the operation is enclosed in a building, operating temperature can be optimized for maximum fish growth. Also, products can be marketed on a year-round basis, opening up new markets for a guaranteed supply. Finally, controlled water re-use systems lend themselves to polyculture and the incorporation of hydroponics, producing a greater variety of products for the marketplace.

The species being cultured, the biomass to water volume ratio, and the percentage of water to be re-used all help determine the equipment required to recycle water. Water quality factors important to aquaculturists (which we often take for granted, especially in open-flow systems) are temperature, salinity, dissolved oxygen content, pH, ammonia nitrite and nitrate levels, and the total organic carbon in the water. This is made up of dissolved organic carbon substances and particulate organic carbon substances. Unless we run into serious problems, we neglect heavy metal levels in our water and potential insecticide levels caused by runoff. These don't concern us, as a rule, until we start trying to find the source.

Total organic carbon is produced as a result of the metabolism of animals in a system, as well as the metabolism of the bacteria or micro-organisms in a system. It is also a result of cell tissue degradation. From the total organic carbon, we get particulate organic carbon, which can be made up of large molecular substances or aggregates of smaller substances. We usually remove them mechanically, by biofiltration. Through biofiltration, organic compounds are converted to inorganic compounds, such as ammonia, nitrites, nitrates, and in some cases, to nitrogen (at the end), which can then go back into the atmosphere. This is mineralization of organic compounds by heterotrophic bacteria, the result of direct metabolic processes by fish and, in our case, by lobsters or many other organisms. In nitrification — the breakdown of the inorganics — we normally see three separate processes: mineralization, nitrification and denitrification.

At the Advanced Lobster Technology Station in Victoria, Prince Edward Island, we draw our water from saltwater wells, drilled out on the wharf. We were fortunate to find salt water under a wharf. Our wells give us seawater at 7-9°C year-round with minimal salinity fluctuations. It is good quality. We don't have to worry about pollution from runoff even though we're in an agricultural area.

Mechanical filtration, in water to be reconditioned, reduces the particulate organic carbon. Methods normally used in mechanical filtration include settling, screening, sand filtration, and diatamacious earth. I don't recommend all of them but, normally, one or two in combination work quite well. We use a homemade settling tank with a flat base which has to be vacuumed out once or twice a week in order to remove the settled-out material at the bottom. Another type of settling tank has a cone bottom and was designed by Harold Rosanthorn and his group in Germany. The dirtiest water goes to the centre at the top and the clean water flows out through a weir system to the outside of the pot. Solid sludge settles to the bottom, and there is an actuated valve there which flushes a small amount every hour or so. The solids can then be used for landfills, fertilizer, or whatever. Thus, the dirty water stays in the middle and the clean water goes around the outside, and most of the larger particulate materials come out in that fashion. It's also beneficial to use some sort of settling mechanism in front of the sand filters to ease the load on them. Sand filters will typically clean to 25 micron particle size. Obviously, with settling you're not going to get down that low unless you have a long residence time.

We have worked with three different types of sand filters, among them gravity-flow filters. The flow rate of this type is about 1 to 1.5 gal/sq. ft./min., but it can reach as high as 8 to 10 gal/sq.ft./min., assuming that you have already pre-screened or pre-settled out much of the larger particulate matter. With a five-foot diameter unit, we can put through 200 gal/min. for 10,000 pounds of fish, and backwash every 24 hours.

If you want very clean water, diatamacious earth can be used behind the sand filters. Personally, I don't see the need for them in aquaculture but they're certainly acceptable for mechanical filtration.

Once the water is mechanically filtered and a lot of the particulate matter has been removed, you must look at biofiltration. Again, there are three steps: mineralization, nitrification and dissimilation. During mineralization, organic compounds are broken down, resulting in the formation of inorganics. This is done by heterotrophic bacteria and requires oxygen. Here we get into nitrification again; it's the oxidation of ammonia to nitrate and is accomplished by autotropes, in particular nitrosomanas and nitrobacter, which requires oxygen. Dissimilation is nitrate respiration -- nitrate ions act as the ultimate hydrogen acceptor to oxygen. This is done under anaerobic conditions. We don't normally use denitrification because it requires a lot of control and denitrifiers tend to throw off hydrogen sulfide, methane and other gases as by-products which requires aeration of the water afterwards. However, in Germany and in other parts of Europe where they use tightly closed systems, they use a denitrification tower.

When we first set up eight years ago, we installed four large biological trickling filters for mineralization and nitrification. They were filled with coche rings or plastic media with water trickling through them. For those in pond culture, the Europeans suggest rotating drums as a type of biofilter. These can be mounted on ponds or on inside tanks and they are responsible, again, for mineralization and nitrification. One denitrification tower in Germany is fed methanol as a source of carbon. Once the water comes out of that, it is aerated in another tank before it goes back into the main stream in order to ensure it isn't carrying any hydrogen sulfide products back into the system.

Another method of getting rid of certain waste materials is by physical absorption using foam fractionaters; the bubbles and dirt accumulated on the foam are collected via the fractionaters. In a foam fractionater at the Biological Institute in Hamburg, Germany, the water is mixed in the bottom chamber and there is a cone at the very top which the foam goes through for collection. We have a similar unit at Victoria. We inject ozone into the fractionater and mix it very rapidly with the water. This enhances the foaming, breaks down some of the dissolved organics and kills a lot of the microbes. The residual is lifted with the foam and dispensed with properly. This absorbs dissolved organic material very well. A lot of material can be gotten rid of in this way, including micro-organisms.

Another absorption process that is used, especially in aquariums, is the activated carbon filter. This can be expensive to operate in high-low aquaculture systems, simply because carbon is expensive. If you are going to use it, do what you can first in the way of mechanical and biological filtration, so that you minimize the load on your carbon. In freshwater, if you want to get into ion exchange, you can use these methods also, as in the removal of ammonia, for example. In seawater, interference from other ions prevents the process from working well.

In studying disinfection, we look at ultraviolet (UV) irradiation as one possible alternative. We developed one homemade method capable of passing 30 gal/min. which would kill all micro-organisms as long as the water going into it was clean. UV deactivates DNA within the cells and kills micro-organisms. If you have dirty water going through, UV is useless because it can't penetrate dirty water. Ozone, in combination with foam fractionation, breaks down organic compounds by splitting C=C double bonds. It not only kills bacteria by breaking down cell walls, but it also breaks down complex organic materials which tend to build up in recirculating systems. They are broken down into smaller molecules, which the bacteria in biological filters can use more readily and, thereby, enhance water quality. Ozone thus has a dual purpose. It controls microbes and prevents proliferation of such organisms. As well, it enhances water quality by breaking down complex molecular organic material. Ozone is a powerful oxidant and has to be used with caution because it will oxidize lobster gills, lobster tissue, fish gills or fish tissue if it gets back to the fish. However it is very short-lived, so that if the contact chamber is removed from the main stream, and the water is back-mixed before it hits your fish again, you will remove any residual oxidants.

In a recirculating system in Germany, at the Biological Institute, the stocking densities are quite high. What especially impressed me was that the system had been in operation for three years, and there had been no water changes. They did bring in 1 to 2 per cent volume make-up per day to make up for spillage and water that had been drained off with the sludge. Their fish are growing and are being put into test markets. In the same system, they are growing eels. The stocking density is about 1 kg for four litres of water, and it would be difficult to get much higher than that. In this system, they are working with six species at a time. They are using settling, biofiltration, and ozonation as their principal methods of water conditioning.

Another thing we have to look at in recycling water is buffering and pH control. The mineral carbonates in the water buffer it, preventing extreme fluctuations in the pH. This is a carbonic acid, carbonate-bicarbonate process, working back and forth as you get pH changing. With animal metabolism, of course, you tend to get acid end-production or acid products and you normally get a drop in pH. So to maintain pH or that buffering capacity of the water, you simply use sodium bicarbonate, ordinary baking soda. It works very well. It can be used quite safely in fresh water, unless you're putting in large amounts and it starts throwing off the sodium balance.

One of the most important things is aeration, the most limiting factor in recirculating systems. Before you get into toxic problems with ammonia, or anything else, you'll run out of oxygen. We use low-pressure, high-volume blowers to generate our air. 80 per cent of the flow in our facility is with air lift pumps, for two reasons: 1) the tanks that we use are 17 ft. high and we have found that our efficiency in pumping with air is, in fact, twice that of pumping with mechanical impeller pumps, and 2) at the same time we're moving the water, we're also aerating it. So, if you have any depth of water and you can incorporate air lift pumps, I highly recommend them.

For water conditioning, unless you are going to close your system down tightly, you can use pre-settling to get rid of the coarse stuff. Our sand/gravel filter is a dual-type unit. It does the mechanical work, takes out the POC and the bacteria that adhere to the sand and gravel and also does the biological work. In our reservoir, we re-aerate with a blower, pump it back up through a UV system into an inner tank and it gravity-feeds back down to the settling tank. We operate this system with a stocking density at 1 kg/15 litres and our volume make-up averages 2 per cent a day.

Qualified technicians who understand water quality and are able to spot trouble are an important part of any recirculating system. They must be able to use standard laboratory equipment, such as pH meters and spectrophotometers. The equipment you install is only useful if you have people who understand it and can use it properly.

In summary, land-based, water recycling systems will contribute more and more to aquaculture. One of the major benefits is that water quality can be managed, whereas in natural aquaculture installations we must accept whatever the environment offers.

USING HISTOPATHOLOGY FOR DIAGNOSING FISH DISEASES

by

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Introduction

Disease diagnosis in all animals, including fish, is a complex process. Figure 1 illustrates some of the steps in the procedure. It involves examination of the diseased animal (the host) and the agent associated with the disease (the pathogen). The major emphasis in fish disease diagnosis has focused on establishing an etiological diagnosis of the identification of the pathogen and, for the most part, has omitted examination of the host (Department of Fisheries and Oceans, 1984; Amos, 1985). However, accurate and comprehensive disease diagnosis, which is required for rational disease treatment, also requires a morphologic diagnosis which is established by an in-depth examination of the host (Humphrey, 1985).

This type of examination is generally divided into the appearance of the affected host grossly and microscopically. Visual examination of the host is called gross pathology and microscopic examination of tissues from the diseased host is called histopathology. The purpose of this presentation is to describe the use of histopathology in fish by illustrating three examples of diseases in fish which required histopathological examination before the disease was accurately diagnosed.

Histopathology - Definition

Histopathology is the branch of medicine which treats the essential nature of disease, especially the minute structural, compositional and functional changes in tissues and organs of the body which cause or are caused by disease (modified from Dorland; illustrated medical Dictionary 24th Ed.) As a working definition, histopathology can be defined as changes in structure, composition and function of tissues caused by disease. By examining tissues histopathologically we are able to classify the types of structural, compositional and functional changes taking place within affected tissue during disease outbreaks. This classification of tissue changes leads us to a morphological diagnosis. Since specific diseases or types of disease cause specific morphological changes, a morphological diagnosis can often lead us to the cause of the disease. Histopathology is, therefore, a tool for disease diagnosis which is not limited by the isolation of live pathogens. Indeed disease conditions associated with pathogens which have died or are difficult to grow _in vitro_, environmental problems, nutritional, genetic, traumatic and toxic conditions can frequently be diagnosed using histopathology.

Case histories of disease condition found in East Coast fish from the files of the fish pathology laboratory at the University of Guelph will illustrate the usefulness of histopathology in disease diagnosis. Lipoid liver disease, nodular gill disease, severe restrictive pericarditis associated with metacercaria of _Stephanostomum_ sp. and proliferative kidney disease illustrate nutritional and parasitic diseases of cultured salmonids which are not diagnosed using routine methods currently employed in fish disease diagnosis.

Lipoid Liver Disease

Rainbow trout from a commercial fish farm were experiencing moderately heavy mortalities. Neither pathogenic bacteria nor virus could be isolated from the dead or dying fish. Samples of the fish were then submitted for histopathological examination.

Histopathology of the liver and pseudobranch revealed widespread single-cell necrosis in both of these organs. Also, many of the hepatocytes contained Ziehl-Neelsen positive intracytoplasmic inclusions, indicating the intracytoplasmic accumulation of ceroid. These lesions are characteristic of lipoid liver disease.

Lipoid liver disease results from fish eating oxidized fatty acids, or rancid oils (Roberts, 1978). An examination of the oil use in preparation of fish feed in this instance was indeed rancid. A new source of oil was obtained and the remaining fish recovered.

Nodular Gill Disease

A commercial fish farm in New Brunswick was experiencing chronic low-grade losses in market-size brook trout. These fish had been examined for bacterial and viral pathogens and none had been identified. Gill, liver, spleen, kidney, heart, intestine and muscle were examined histologically.

Lesions were confined to the gills. There was massive epithelial hyperplasia resulting in fusion of the gill Camellae and fusion of adjacent gill filaments. Affected gills were covered with amoebic-like protozoa, characteristic of nodular gill disease (Daoust and Ferguson, 1985).

These fish stopped dying following treatment with 150 ppm to 200 ppm formalin baths for one hour, once on each of three consecutive days. In some cases, daily formalin baths for up to four consecutive days may be required to alleviate mortalities due to nodular gill disease.

Severe Restrictive Pericarditis

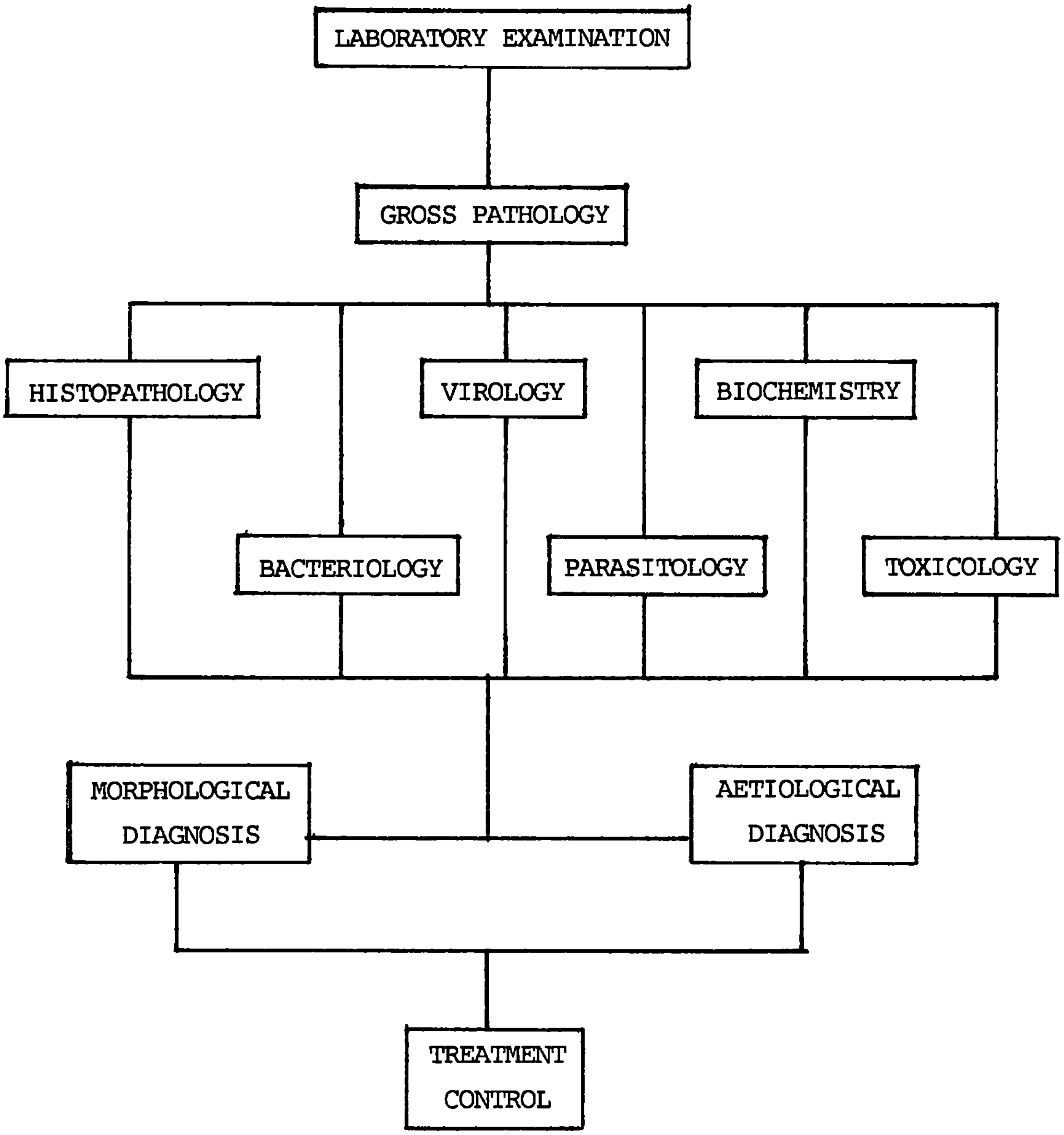
The third example of using histopathology for diagnosing fish disease comes from a case where rainbow trout being reared in sea cages in Prince Edward Island were experiencing severe mortality. Again bacterial assays failed to reveal the presence of pathogenic bacteria.

Tissues examined histologically included gill, liver, heart, kidney, spleen, intestine, pancreas, brain, eye and flank muscle. Significant findings were confined to the heart. The heart of all six fish were encased in a thick fibrogranulomatous layer of inflammation. Encysted within this thick inflammatory pericardial lesion were small metazoan parasites with vential and oral suckers. This was a case of very severe restrictive pericarditis which was judged to be damaging enough to kill these fish.

Further examination of these metacercaria indicated that they were likely Stphenastomum sp. (Dr. Sharon McGladdery, DFO, Moncton). By placing cages well away from the snail intermediate hosts, further problems with this parasite were greatly reduced.

These cases illustrate the need to go beyond the isolation and identification of bacterial and viral pathogens when attempting to diagnose fish diseases. Histopathology is a very powerful diagnostic tool which is commonly used in human medicine and other areas of veterinary medicine. With the growth of intensive aquaculture, the diagnostic service sector will also grow. Histopathology is one of the growth areas which will be useful in identifying and defining new disease problems associated with the high-density rearing system used in commercial aquaculture.

Figure 1


LABORATORY EXAMINATION
GROSS PATHOLOGY
HISTOPATHOLOGY
VIROLOGY
BIOCHEMISTRY
BACTERIOLOGY
PARASITOLOGY
TOXICOLOGY
MORPHOLOGICAL DIAGNOSIS
AETIOLOGICAL DIAGNOSIS
TREATMENT CONTROL

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THE PREVENTION OF FISH DISEASES BY VACCINATION

by

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Although diseases have affected cultured fish stocks throughout the world for many years, recent concentrated fish-rearing activity has brought into focus the economic significance of disease losses.

Fortunately, vaccination is coming to the aid of fish farmers just as it has for farmers raising domesticated animals. Vaccination has played a major role in creating a sophisticated poultry industry. We predict it will do the same for aquaculture.

I work with Aqua Health Ltd., which was formed 2 1/2 years ago, and dedicated to developing, producing and making available to fish culturists throughout the world treatments to prevent disease. Our major effort has focused on bacterial diseases, because a commercial vaccine to prevent these diseases was considered technically achievable.

Prevention, by vaccination, is now possible for furunculosis, caused by *Aeromonas salmonicida*; vibriosis, caused by *Vibrio anguillarum* and *Vibrio ordalli*; and enteric redmouth disease, caused by *Yersinia ruckeri*.

The commercial development of such vaccines is complicated. It begins with the presence of a pathogen or disease agent that may cause severe economic losses in aquaculture. This pathogen is isolated, cultivated and characterized. Experimental vaccines are then prepared and administered to fish. A sophisticated disease containment laboratory is utilized to evaluate the level of disease protection offered by vaccination. The best vaccine preparations are then chosen and, through microbiological research methods, techniques are formulated to manufacture them on a commercial scale.

We have one such laboratory in Toronto. This is a temperature-controlled, flow-through system, where the effluent is completely disinfected so we can, with good conscience, work with pathogens. We can test vaccines and use systems that are quite similar to those in nature to quantify just how much protection we are providing.

After the manufacture of several consecutive production lots (three in United States and at least two in Canada), they are tested on fish for safety and potency. This, of course, preceeds licence approval for use in the industry.

In July, 1986, we opened a modern bacterin production plant in Charlottetown. The main component of the plant is a large 450-litre (100-gallon) fermenter. As the fermenter is sterilizable in situ, we can control oxygen and many other parameters. This vaccine plant is now approved for veterinary vaccine production and distribution in the United States, England and Canada. Such approval normally permits access to the whole world.

What should you expect from vaccines? A number of things. Good vaccines should **prevent disease.** This will **increase production.** One of the reasons we have disease is that the causative agent is present in large numbers. If you vaccinate and lower the incidence of disease, however, you minimize the number of bacteria or causative agents. Thus vaccination **diminishes the disease pool.**

Often, too, we've thought about feed conversion and how vaccination affects it. Recently, Mike Horne at Sterling University put together some data, both for economic cost-benefit analysis and for feed conversion assessment. It shows that you can **increase feed conversion** by vaccinating. We shouldn't be surprised. If you're preventing disease and making the animals healthier, you should expect an improvement in the way they convert food.

How are fish vaccines delivered? They should be delivered orally, but I'm not sure when we'll have oral vaccines. Today's vaccines are delivered by **immersion**, by **spray** and by **injection.** You can choose. And it's no longer necessary to inject every fish, if you don't want to.

Immersion involves dipping fish in diluted bacterin. Displacement is used to indicate how many groups of fish have been vaccinated and how many fish are in each group.

Spray is valid with larger fish but requires special, rather expensive equipment. For that reason, I will limit discussion to the other two options.

Injection through the intraperitoneal (IP) route was, in the past, done using the Cornwall repeating syringe. We're now using a syringe manufactured in England which was developed for the hog industry, and it's much better. There are several mountains to climb, however, in our approach to injecting fish. One of the main ones is the mental block attached to the work involved in injecting large numbers of fish.

Table I

LABORATORY TESTING OF AQUA HEALTH FISH VACCINES

Disease(s)	Vaccine(s)	Species	Mortality (%)	
			Vaccinates	Control
Furunculosis	FUROGEN	Coho (injection)	10	80
		Atlantic salmon (injection)	10	87.5
		Brook Trout (injection)	2.2	83
	FUROGENb	Atlantic salmon (immersion)	25	80
		Rainbow trout (immersion)	8	41
Vibriosis	VIBROGEN	Atlantic salmon (injection)	2.5	62
		Atlantic salmon (immersion)	2.5	62
		Coho (immersion)	0	84
Enteric Redmouth Disease (ERM)	ERMOGEN	Rainbow trout (injection)	2.8	61.5
		Rainbow trout (immersion)	10.3	61.5
		Rainbow trout (spray)	10.8	61.5
Gaffkemia (in lobsters)	GAFFOGEN		N/A	N/A

Table I lists the diseases we're working on, the vaccines, by name, and the species tested to date. Our laboratory uses a bath challenge system which simulates nature to examine the disease prevention attributes of every production series. Table I also shows the level of protection conferred on several species of fish and the effective prevention of furunculosis, vibriosis, and ERM which results. Gaffogen, an injectable vaccine used to treat gaffkemia in lobsters, has only recently been licensed for use by the lobster-holding industry.

Table II

SUMMARY OF FUROGEN b FURUNCULOSIS IMMERSION VACCINE POTENCY TESTS

Lot	Fish Species	% Mortality		RPS
		Vaccinates (%)	Control (%)	
801	Atlantic salmon	25	80	69
802	rainbow trout	41	83	51
803	rainbow trout	21	63	67
803	rainbow trout	8	41	81

$$\text{Note RPS} = 1 - \frac{\text{\% mortality in vaccinates}}{\text{\% mortality in controls}} \times 100$$

Table II is a summary of the results of a series of potency tests involving FUROGEN b furunculosis immersion vaccine. The column on the right shows the RPS, relative percent survival, (100 being perfect).

Prevention of disease under laboratory conditions spotlights the more important question -- what happens under actual field conditions? In the field, vaccines do prevent disease, and we will evaluate the economic significance of the field data outlined below, (Tables III - VI).

Table III

VIBROGEN FIELD TRIAL (for the prevention of vibriosis)

Species - Rainbow Trout

	Fish (#)	Mortality (%)
Injection Delivery	16,000	2.9
Immersion Delivery	10,000	5
Unvaccinated Controls	10,000	29.5

In the field trial described in Table III, using rainbow trout in a salt water cage culture setting, fish vaccines effectively increased production by 24.5 per cent (immersion vaccination), or 26.6 per cent (for injection vaccination). In a population of 100,000 fish, this vaccination would, therefore, directly result in production of 24,500 - 26,600 additional fish.

Table IV presents field trial data for an enteric redmouth (ERM) vaccine, and demonstrates a potential increased production level of 17.1 per cent. This translates into the survival of an additional 17,100 fish when 100,000 fish are immunized.

Table IV

ERMOGEN FIELD TRIAL (To prevent Enteric Redmouth Disease)

Location - Denmark
Species - Rainbow Trout

	Fish (#)	Mortality (%)
Vaccinated	82,500	4.7
Controls	26,400	21.8

Although the control of furunculosis has been an elusive goal, the data in Table V shows that vaccines can decrease losses by 26.4 per cent in the presence of a furunculosis epizootic. If you rear 100,000 fish, this reduction would increase your production by 26,400 fish, a significant economic bonus. Table VI provides similar data, with similar implications, for an immersion furunculosis vaccine.

Table V

FUROGEN FIELD TRIAL (For the prevention of furunculosis)

Injection vaccination

Species - Brook Trout

	Fish (#)	Mortality (%)
Vaccinated	5,275	9.7
Controls	7,000	36.1

Table VI

FUROGEN b FIELD TRIAL (immersion vaccine for the prevention of furunculosis)

Species - Atlantic Salmon

	Fish (#)	Mortality (%)
Vaccinated	15,852	5
Control	211,780	55

Having worked with Aeromonas salmonicida for many years, I've often thought about whether or not a vaccine for this bacterin would have any effect in preventing furunculosis caused by atypical isolates. We have a recent report, for example, from a goldfish operator in California that he has almost eliminated ulcer incidence in goldfish using an immersion vaccine for furunculosis.

Both Sweden and Norway experience furunculosis caused by typical and atypical Aeromonas salmonicida, and we have done field tests with the immersion furunculosis vaccine in Sweden. In both instances, the tests showed that it's very potent and that the increase in production is significant, some 10 to 15 per cent. So vaccines will work against atypical or typical isolates of Aeromonas salmonicida.

I was talking with a friend from Quebec who told me that researchers there have been observing the migration patterns of Atlantic salmon, and, that they can triple the rate of return of released fish which have been vaccinated by injection for vibrio and furunculosis.

Table VII

LAB EFFICACY OF FUROGEN INJECTABLE VACCINE IN VARIOUS SALMONID SPECIES

Species	Number of fish	Percent Loss	RPS	Control Loss
Coho Salmon	40	10	87.5	80.0
Atlantic Salmon	30	10	87.5	74.2
Chinook Salmon	40	15	70	51.8
Brook Trout	45	2.2	97.3	82.9

Table VII illustrates the efficacy of Furogen injectable vaccines in various salmonid species. The relative survival rate, as you can see, is very high.

The first real inkling we had that this vaccine performed as well in the field as in the lab was at Lac des Ecorces with speckled trout, as shown in Table VIII. In this case, there was a difference in mortality of 36 per cent in the controls and almost 10 per cent among the vaccinates, for a relative survival rate of 73 per cent. In other words, you get an approximate increase of 25 per cent in production following vaccination.

Table VIII

FIELD EFFICACY OF FUROGEN (lot 203) IN SPECKLED TROUT at Lac des Ecorces during an ongoing epizootic from June 22, 1984 to July 30, 1984. Fish were vaccinated on May 14, 1984.

Group	Fish (#)	Mortalities (#)	Loss (%)
Vaccinated	5275	510	9.7
Controls	6989	2524	36.1

People should keep in mind the cost when they are considering whether to vaccinate and whether to use immersion or injection for vaccination. In our example, we are only considering the cost of the vaccine, not of the injectors or the people doing the injecting or carrying out the immersion. It is based on a vaccine price of about $100 a litre. Injection costs for the vaccine are about one cent per fish. With immersion, the cost of vaccine varies depending on the size of the fish. Table IX gives the price per fish as the weight increases.

Table IX

COST OF VACCINATION (IMMERSION)

Fish size (g)	Cost/fish (cents)
2.0	.2
4.5	.45
11	1.1
22	2.2
100	10.
250	25.
450	45.

Table X shows the number of fish that can be vaccinated with one litre of vaccine, according to size. You go from 50,000 fish, if they're two-gram size down to 222 fish of 450 grams (1 lb.) with one litre of vaccine.

Table X

COST OF VACCINATION

Size of Fish		No. Fish Vaccinated/litre vaccine	
#/lb.	g/fish	Immersion	Injection
227	2.0	50 000	10 000
100	4.5	22 000	10 000
40	11	9 090	10 000
20	22	4 545	10 000
4.5	100	1 000	10 000
1.8	250	400	10 000
1.0	450	222	10 000

That's why it's so expensive to vaccinate large fish by immersion. In contrast, the cost of vaccinating by injection doesn't increase. You can inject 10,000 fish per litre, no matter what the size.

Again, we should expect vaccines to **prevent disease, increase production, diminish the disease pool** and **increase the level of feed conversion.**

Information on feed conversion was gathered in four field trials conducted by Mike Horne. This work was done in Denmark and England with the ERM vaccine. In the data put together from these four trials, the feed conversion ratio was increased from 2.14 to 1.8 after vaccination, which is significant. Table XI shows typical cost benefits you can expect from using vaccines.

Table XI

COST OF VACCINATION

		Number of Fish (X1000)	% Mortality	Value of Additional Products due to Vaccination ($ Cdn.)	Cost of Vaccine ($ Cdn.)
Trial 1	V	10,095	1.2	228,627	24,000
	C	1869	3.6		
Trial 2	V	9727	1.4	1,018,856	22,500
	C	1521	12.5		
Trial 3	V	3135	1.4	263,292	7,900
	C	831	10.3		
Trial 4	V	82	4.7	13,231	216
	C	26	21.8		

The mortality percentage, the third column, shows small differences in the first trial (about 2 per cent) and in the second trial, about 11 per cent. So there's a significant difference in the vaccinate/control ratio. And there's quite a difference in the cost-benefit of vaccinating. The third column shows the additional value in Canadian dollars of the product. In the first trial, if you take the number of vaccinates and controls and the difference between vaccinating and not vaccinating them all, the increase in revenue was more than $228,000, while the cost of vaccine was $24,000. In the second trial, and this involves again about an 11 per cent difference between controls and vaccinates, the additional value of product is more than a million dollars. Again, the numbers of fish were the same, so the cost of vaccines was also about the same, $22,000. The third trial involved a 9 per cent difference between controls and vaccinates, and the increase in the value of fish was $263,000 while the cost of vaccines was $7,900. In the fourth trial, the numbers of fish were much smaller. The difference is about 15 per cent, so it doesn't take as many fish to give you a large cost benefit -- $13,000 increase in produce for about $216 worth of vaccine.

This is the second year that Aqua Health has been in the marketplace and, in 1986, 115 million fish were vaccinated. We appreciate it when people in Canada, Europe and the United States agree to work with us to conduct field trials. I think it's our mutual responsibility to co-operate in this way. It's the kind of thing, whether it be diets or vaccines, that produces good products and a healthy industry.

PARASITES AND THEIR RELEVANCE IN AQUACULTURE

by

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Moncton, New Brunswick

In the wild, most parasites cause little, if any, harm to their hosts. This is generally a reflection of the relatively low levels of infection found in wild hosts as compared to those found in aquaculture. The probability of any single parasite (egg, cyst or other infective stage) ever reaching maturity is phenomenally small. In the aquatic environment, parasites have to deal with variable environmental influences, as well as host availability or lack of it.

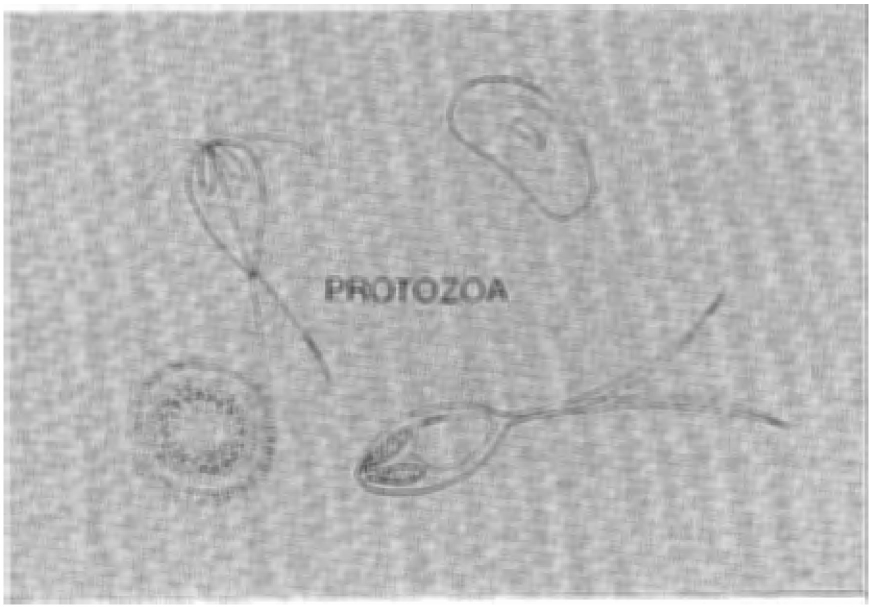
Unfortunately, the characteristic used by most parasites to enhance transmission from one host to another in the wild can cause quite devastating results under aquacultural conditions. That characteristic is prolific reproduction.

A captive concentration of suitable hosts is "parasite paradise". The probability of successful transmission is much higher and parasite reproduction dramatically increases, causing levels of infection much higher than found in the wild. Under aquacultural conditions, therefore, a formerly innocuous parasite can become a major headache.

Where there is potential for a parasite problem (eg. stock acquired from a naturally parasitised population, stock surrounded by a watershed containing wild fish with parasites or where there is an ongoing parasite problem), effective control has to be based on an understanding of the type of parasite involved and its relationship to the stock species.

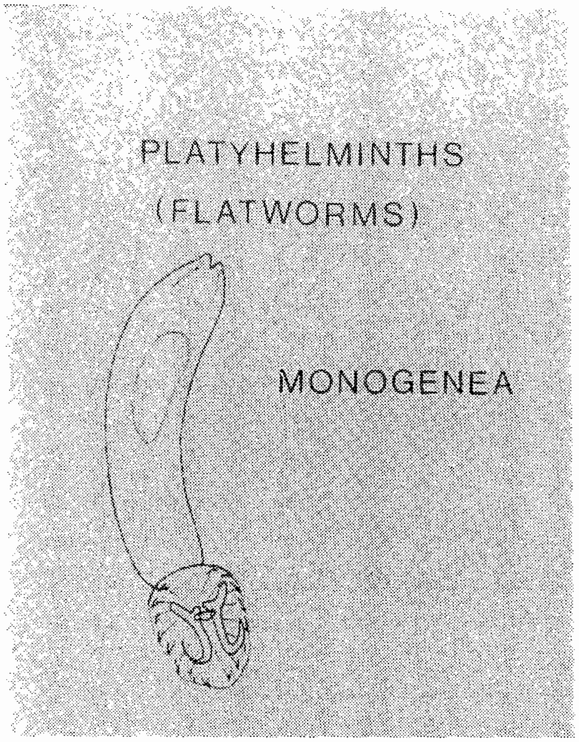
The types of parasites that affect the aquaculture industry can be divided into five basic groups: Protozoa (single-celled parasites), Platyhelminths (flatworms), Acanthocephalans (thorny-headed worms), Nematodes (roundworms) and Crustaceans (fish-lice, gill maggots, etc.).

The protozoans are the smallest, but probably the most devastating parasites to be encountered by aquaculturists. They comprise a wide array of single-celled organisms, some of which are external parasites of the skin, fins and gills; eg. Costia, a flagellate which is transmitted from fish to fish during a free-swimming stage, and Trichodina, a ciliate which is transmitted the same way. Some of the protozoans are internal parasites of the muscle (eg. Henneguya) or gut (eg. Hexamita), transmitted in their spore stages when released from infected fish and ingested by other fish.

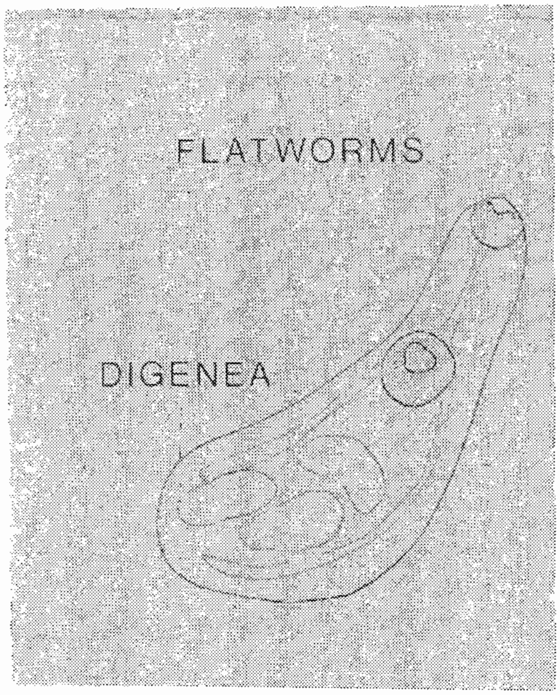


The platyhelminths, or flatworms, are made up of three different groups, easily distinguished from each other.

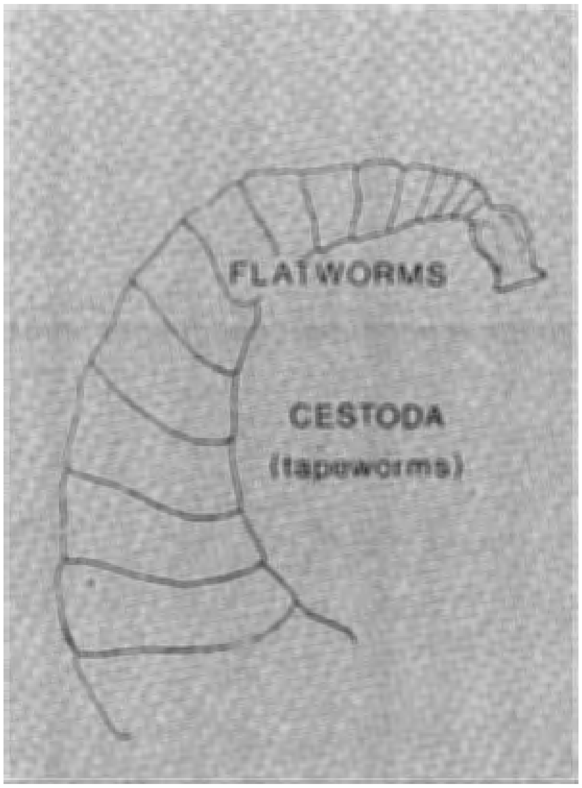
The Monogenea are external parasites living on the skin, fins and gills of their hosts. They possess a striking posterior attachment organ (opisthaptor) which may be made up of hooks, suckers or clamps, depending on the type of monogenean (eg. Gyrodactylus, a common parasite of salmonids, uses two large hooks surrounded by a circlet of smaller ones). Infection occurs directly from fish to fish.



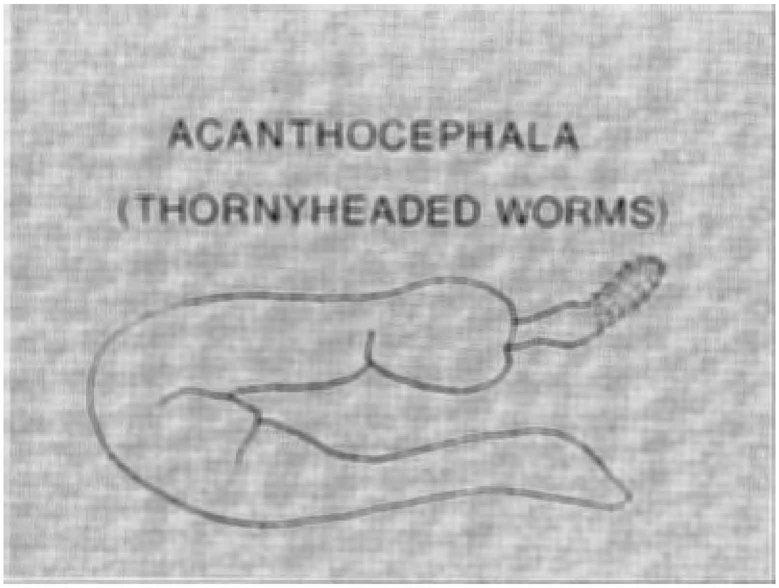
The Digenea (flukes) have two suckers, one anterior and one ventral, instead of a posterior attachment organ. They require more than one host to complete their life cycles: a definitive host, in which they mature and reproduce, and one or two intermediate hosts, which are used during their larval stages to gain access to the definitive host. The adults generally live harmlessly in the gut of the fish; however, where the fish is host to a larval stage, health problems may arise. For example, the larvae of the eye-fluke, Diplostomum, can encyst in the eye lens causing glaucoma or blindness, and larvae of the digenean Apophallus can encyst under the skin of the fish, causing "Black Spot" disease. Both species infect the fish after being released from freshwater snails, and the adults mature in fish-eating birds.



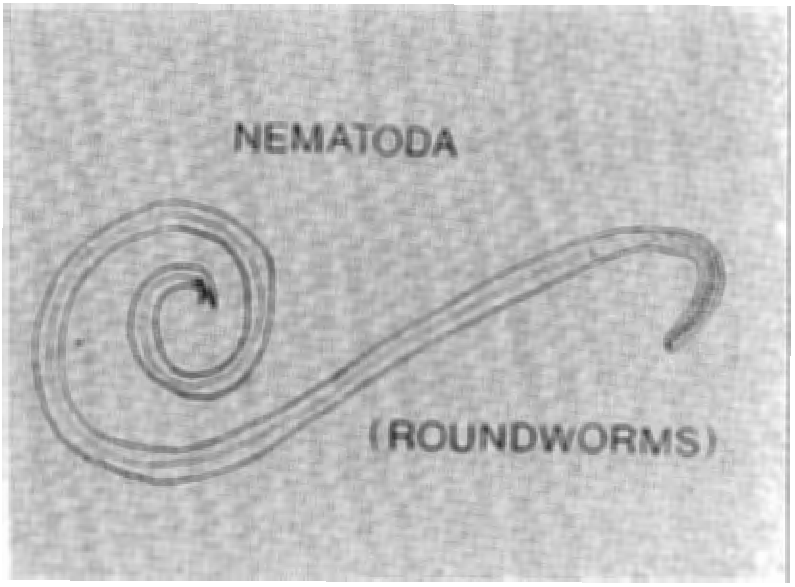
The third group of flatworms are the Cestoda, or tapeworms, which have an anterior attachment organ (scolex), located at the narrow end of the adult worm. As with the digeneans, it is generally larval tapeworms that cause problems in farmed stock. Larvae of the "Gull Worm", Diphyllobothrium, migrate through the muscle tissue of their hosts where they finally encyst. Another Diphyllobothriid is the Broad Fish Tapeworm which can infect man, if eaten in raw or undercooked fish. Infection of the fish occurs when they eat infected copepods, and the adults are found in gulls, or, as in the case of the Broad Fish Tapeworm, in fish-eating mammals.



Acanthocephalans, or thorny-headed worms, are distinguished by an eversible, spiny proboscis which the adults use to anchor themselves in the gut wall of their hosts. The larvae usually live in freshwater crustaceans and have not, as yet, been implicated in farm fish health problems.



The Nematoda, or roundworms, have no specialized attachment apparatus and are superficially simple in form. A wide range of nematodes infect aquaculture stock. Adults living in the gut do not generally cause health problems; however, Philnema is found in the body cavity where it can elicit severe visceral disruption and may even sterilize the fish. Larval nematodes may cause similar problems, if present in large numbers. Fish become infected when they eat infected copepods.



Most crustacean parasites in farmed fish are copepods, so that these invertebrates are of relevance to aquaculture, not only as intermediate hosts of flatworms and roundworms, but as parasites as well. The sea-louse, Lepeophthirius, appears similar to a free-living copepod and attaches to anadromous fish while at sea. They feed on surface tissues, but fall off in freshwater, leaving flesh open to secondary infection by bacteria or fungi. The "gill-maggot", Salmincola, infects salmonids in freshwater, but the adult females can survive, even if the fish goes to sea. In freshwater, they produce numerous batches of hundreds of eggs which rapidly increase infection levels to pathogenic levels in closed conditions.

Having found a parasite problem in an aquaculture situation and having identified it to the level of protozoan, platyhelminth, acanthocephalan, nematode or crustacean, how do you control or eradicate it?

For external parasites (some protozoa, monogeneans and crustaceans), most treatments are topical, administered in baths. For stubborn parasites, such as adult Salmincola, manual removal may be necessary, with a supplemental treatment to prevent secondary pathogens.

For internal parasites, direct treatment may not be possible. Gut parasites may be treated via foodstuffs, but reinfection also has to be controlled. This may involve eradication of snail or copepod intermediate hosts, or by screening off ponds from fish-eating birds or mammals.

In summary, parasites are to aquaculture what herbivorous insects are to agriculture -- all pervasive pests. As aquaculture expands and adopts new techniques, parasites will continue to emerge to take advantage of each situation.

The best defence against them is early detection through recognition of the parasites involved and application of the appropriate direct or indirect treatment. In cases where there are no known or effective treatments, an understanding of the life cycle of the parasite is invaluable for choosing a new farm site, out of reach of that parasite.

OVERWINTERING

by

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Overwintering is a major challenge for aquaculturists on Prince Edward Island, and I think we have a similar situation in a large part of the Gulf, certainly the southern Gulf, because of super-chilling throughout the winter. In some of our bays and estuaries, Fisheries and Oceans has recorded temperatures as low as -2°C, and we believe wind chill is a significant factor in these temperatures. We have recorded data over the past several years in several areas which confirms this assumption. In most of our bays and estuaries on Prince Edward Island, where there are opportunities for culturing fish, there is shallow water. Here, in cold weather, we get almost a complete mixing, at least until ice cover, and this mixing has been a major problem (because it lowers water temperature so drastically).

In an effort to develop appropriate overwintering technologies for P.E.I., Fisheries and Oceans has supported several different approaches. However, until this year, these have met with limited success.

One of the first methods tried was moving fish well up into the head waters of the same bay or estuary in which they were reared in the summer. We built a metal frame inside of which we tied a nylon mesh net. We then put 1,000 fish into the net and dropped it to the bottom in brackish water. This approach did not work, however, and it resulted in the total loss of the fish. A Ryan thermograph at the site indicated that the temperature had dropped below the -7°C that seems to be the critical low point.

A second approach we have used relatively successfully is transferring fish back into freshwater in mid-November until early May. This technique will work with minimal loss to stock if you are careful in transit. The fish will adjust quickly to the freshwater environment in November, and because of their size, will adapt quickly to seawater the following spring. This approach can be expensive. Additional capital equipment must be available in the freshwater location, and the labor and capital costs involved in transferring the fish can be significant. As well, the stress associated with the move and need for the fish to adjust their physiology to new environments can increase the probability of loss.

This winter, we are conducting three overwintering trials. On Lennox Island in Malpeque Bay, we're trying a European idea. (Figure 1) We are using a cage with a dome which is filled with air regularly. This allows the fish to vent. Dr. Richard Ablett from the Technical University of Nova Scotia (T.U.N.S.) has carried out similar experimental work at the Marine Center at Dalhousie University. The results are not available yet. But we, in a sense, are copying his work in a field application. The Lennox Island site chosen was in 35-38 feet of water, 150 feet from the wharf. The cage was anchored by placing a large (2,000 lb.) weight on the bottom. The anchor was equipped with a block which would allow a wire cable to freely pass through. The cable travels along the river bottom to the base of the wharf where it passes through a second block. From here, it extends up the face of the wharf to a winch. The cage with its dome is buoyant, and had to be drawn down by the winch. This allowed us to raise and lower the cage from shore for maintenance and feeding.

The fish were installed in the cage in early December and drawn to the bottom. Ryan thermographs were attached to the cage, one at the bottom and the second five feet from the surface. Heavy winds this past fall caused super-chilling problems, with temperatures dropping to -2°C, killing all the fish in the cages. The concept, from our point of view, is very good, if environmental conditions permit, and is one that will prove appropriate for many locations. The overwintering cage frame could be integrated into a summer rearing facility and, by adding a domed top each December, could be sunk for the winter months, and refloated the following spring (at which time the dome could be removed). However, we see limited application for this technology around Prince Edward Island. It is not suited to local conditions.

A second overwintering approach tried in the Lennox Island area was the construction of a shore-based tank facility. It is capable of drawing freshwater (7°C) and seawater (-2°C) from the Malpeque Bay. By blending the two, growers will be able to control temperatures and will have no problem in rearing fish winter or summer.

Another overwintering approach, which appears to show great promise, is a system which is now in operation at Sefton Dixon's site on the Fortune River. (Figure 2) The system is a modified summer seawater rearing facility, which has a high capacity freshwater pumping capability on shore, allowing Sefton to supply 7°C water to his nearby rearing cages. The summer rearing cages have been modified by adding, to the outside of the nylon mesh nets, a tarpaulin skirt which extends approximately eight feet deep. In effect, the last two feet allow the tide to flow freely through the net.

The water supply from shore is provided by a 4 X 4 centrifugal pump powered by an 18 h.p. diesel and/or a 3 h.p. electric motor. The water is drawn from a well six inches in diameter, approximately 80 feet deep, with a water level only four feet below ground level. The water is transported through a four-inch line to the cage, where it is distributed between the two pens using a manifold. There are a good number of engineering details which have to be worked out before a larger system like this can be made, but it appears to be functioning quite well.

We are monitoring the temperatures and salinities both inside and outside the cages throughout the winter. We have approximately 400 Atlantic salmon in one cage and 1,500 rainbow trout in the second. The fish have been offered feed throughout the winter and appear to be doing well. The

Atlantic salmon feed vigorously in December, slowing now to a point where feeding is occasional. Atlantic salmon tend to stay on or near the bottom of the cage in the cooler areas, and, in fact, some losses have occurred, caused by suspected super-chilling below the area of the tarpaulin. The rainbow trout, on the other hand, are feeding well. They appear to be staying close to the top of the water, and will show substantial weight gain throughout the winter.

The water temperatures outside the cage were in the range of 0°C to -2°C throughout the winter, while inside the cage, with the addition of approximately 75 gal/min. of 7°C water, the temperature can be maintained at 1.5°C or higher.

There remain some unanswered questions regarding the problems associated with ice breakup and whether or not the system can be held in place during this time. Also, the reduced salinities (15 - 17 ppt) in the cages may affect the salmon and reduce their feeding response, so they may not gain much weight over the winter. Some modification to the skirt is needed to ensure it stays down in the winter because a brief surge of -2°C seawater could cause heavy losses.

We remain quite excited about this method, as P.E.I. is generally noted for large quantities of 7°C ground water, either fresh or seawater. This technology will, therefore, have broad application on P.E.I. as an overwintering strategy. The capital costs are relatively high for the shore-based pump, but the addition of a inexpensive skirt will allow the fish farmer to utilize summer rearing equipment year around. The operating costs for the pump would occur only during four months of the year; the equipment could be allowed to stand idle throughout the remainder of the year.

The third approach is a shore-based seawater well installation. Investigative work carried out last summer indicates the availability of large quantities of brackish water at 8°C from seawater wells. A land-based site will be a major asset to the development of an Atlantic salmon rearing industry by providing an opportunity to maintain a certifiable (FHPR) broodstock facility on shore. The discharge from this facility could be collected and distributed to finger-like wharf projections where the operator would be able to utilize the Dixon technology to overwinter both salmon and rainbow trout. The salmonid rearing industry is thus continuing to develop on P.E.I., and with the demonstration of these new overwintering techniques, there will be an even greater acceleration in the near future.

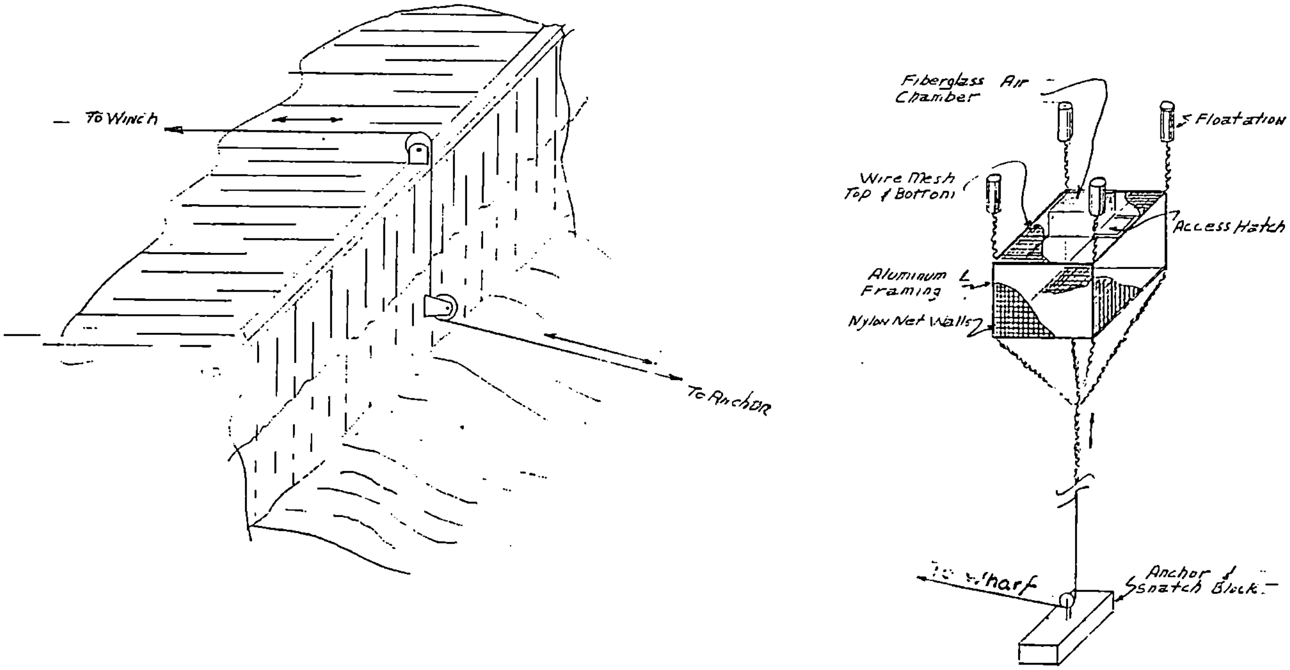
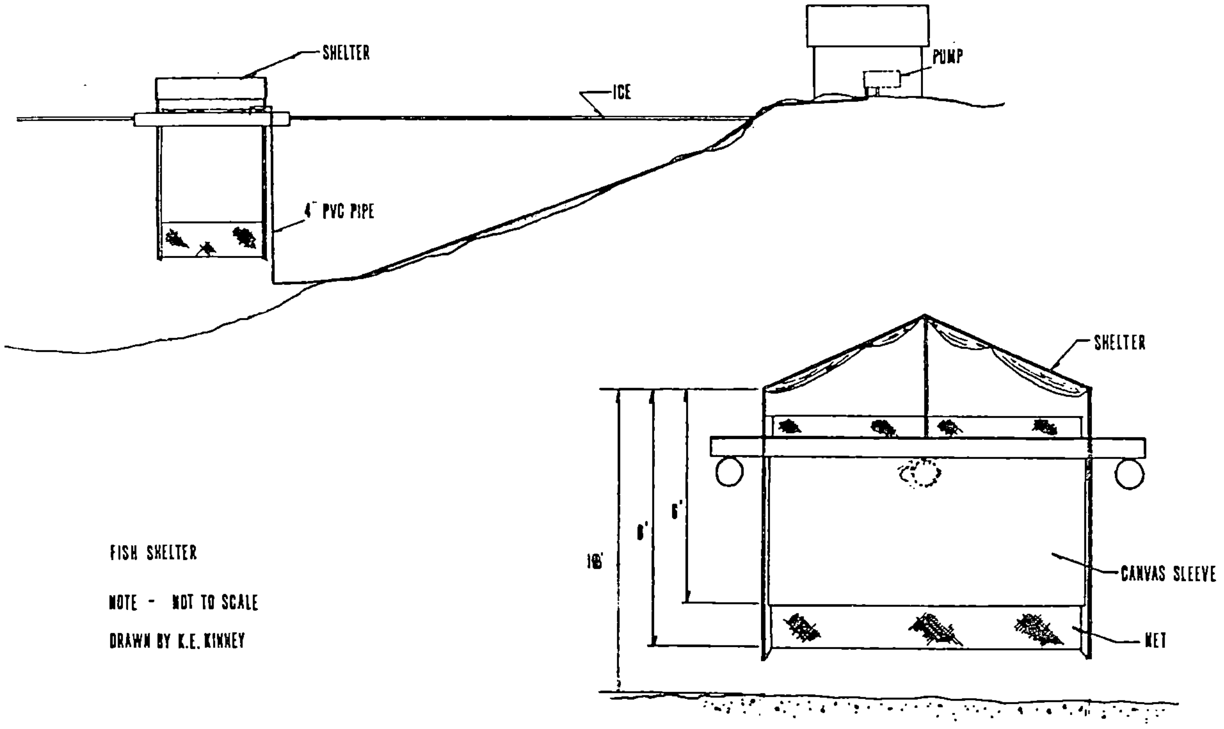


Figure 1. European technology adapted to Local conditions By Lennox Island Band Council Lennox Island, P.E.I.

Figure 2. **BROOK VALLEY MARINE FARMS FORTUNE, P.E.I. CANADA**



ARTIFICIAL RECONDITIONING, SURVIVAL AND GONADAL MATURATION OF ATLANTIC SALMON KELTS IN SALTWATER AND SURVIVAL OF THEIR F1 PROGENY

by

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INTRODUCTION

Canadian Atlantic salmon, Salmo salar L., stocks declined dramatically during the past two decades in response to over-harvesting and changes in river conditions. Since Atlantic salmon are distinct genetic stocks adapted to environmental conditions encountered during their freshwater and marine life stages, recent stock rehabilitation efforts have been constrained by the scarcity of certain genetic broodstocks.

Although post-spawning survival is high in freshwater (White, 1942; Cutting, 1968), and Atlantic salmon have been known to spawn as many as five or six times in the wild (Ducharme, 1969), kelt survival at sea is low (Calderwood, 1927). Along Nova Scotia's Atlantic coastline, only 4-10 per cent return from their second sojourn at sea to spawn again. This is a serious loss of potential spawners, as well as an economic loss.

Previous studies have shown that some salmon kelts held in captivity would feed, regain condition (White, 1942) and spawn (Ducharme, 1972). However, the resulting progeny died soon after hatching. The purpose of the study carried out from 1973-1980 was to rear salmon kelts in two salinities to determine whether viable progeny could be produced.

METHODS

Atlantic salmon kelts from the LaHave River, Nova Scotia, were obtained in early December, after spawning at Coldbrook Fish Culture Station. Rearing facilities were located at Ruth Falls, Sheet Harbour, Nova Scotia, where both fresh and saltwater supplies were available.

Summer rearing facilities consisted of six 3 m circular FRP tanks suppled with either 16 o/oo or 28 o/oo saltwater from an aeration and mixing tower at 227.5 l/min. to each tank. Fifty 1-sea-winter salmon kelts or 90 kg of combined 1-sea-winter and 2-sea-winter salmon kelts were placed in each 3 m tank at the beginning of the summer. Winter rearing facilities in the field laboratory consisted of 3 m and 2.4 m circular FRP tanks supplied with saltwater at 28 o/oo at a rate of 227.5 l/min and 113.7 l/min, respectively. In winter, saltwater was recirculated through two 76.2 cm diameter PM3 Jacuzzi fiberglass permanent media sand filters at a rate of 278.2 l/min per filter; 101.4 l/min saltwater at 28 o/oo was added to the system constantly with an equal amount of discharge. Water from the filters entered a head tank and tumbled through an aeration trough into an ultraviolet water treatment chamber. During the winter, the loading rate of the tanks was reduced 60 per cent. Salinity acclimation occurred at a rate of 2 o/oo per day whenever kelts were moved to freshwater, 16 o/oo or 28 o/oo.

Reconditioning was studied in three different rearing regimes the first year.

Group I: 28(W1):16(S1) - Salmon kelts were acclimated to 28 o/oo in the heated laboratory in early December where water temperature was maintained at 4°C by recirculation for the first winter of rearing (W1). Kelts were re-acclimated to 16 o/oo the first week of July for summer rearing (S1). The natural photoperiod was simulated, using General Electric cool white fluorescent light tubes controlled by timers during the winter; kelts were exposed to natural light during the summer.

Group II: F(W1):16(S1) - Salmon kelts were reared in a freshwater concrete holding pond from early December to early May at ambient river temperature. These kelts were acclimated to 28 o/oo by mid-May and re-acclimated to 16 o/oo the first week of July for summer rearing. Salmon kelts in this group received natural photoperiod throughout the first year of the study.

Group III: F(W1):28(S1) - This experimental group was also reared on natural photoperiod and ambient river temperature in the freshwater holding pond during the winter. Salmon kelts were acclimated to 28 o/oo in early May and remained at this salinity for summer rearing.

In early September after the first year of rearing, all salmon kelts were acclimated to freshwater for spawning since it was not always possible to differentiate between sexually mature and immature kelts. After spawning, salmon were again segregated into freshwater and saltwater groups for overwintering (W2); however, during the second summer of rearing (S2), all kelts were acclimated to 16 o/oo in early July. The two groups studied the second year were **Group I: 28(W2):16(S2)**; **Group II: F(W2):16(S2)**. Both groups were acclimated to freshwater by early September for spawning.

A moist pellet broodstock diet was prepared twice weekly and was immediately frozen in 2 kg plastic bags. Freshly thawed pellets were administered by hand twice daily, at 8 a.m. and 6 p.m., until kelts ceased feeding.

Water chemistry data were collected daily. Salinity was measured using a YSI salinity meter; temperature was measured using a Ryan D-15 continuous recording thermometer, and dissolved oxygen levels were determined using the Winkler idiometric method.

Growth characteristics were determined by mid-monthly sampling over a two-year period as follows: 1- December 1973; 2- April 1974; 3- August 1974; 4- December 1974; 5- April 1975; 6- October 1975. Live weight was determined to the nearest 1.0 g; fork length was measured to the nearest 0.1 cm, and condition factors were calculated as $K = W \times 10^6/FL^3$.

After spawning, eggs were water-hardened for three hours, disinfected with 1 per cent solution of polyvinyl-pyrrolidone-iodine (PVPI) for 10 minutes and rinsed for 20 minutes. Egg number was determined by the displacement method (Burrows, 1951); egg diameters were measured in a 15 cm egg trough (von Bayer, 1910). Specific crosses between reconditioned kelts and wild or hatchery-return salmon were carried out and were kept separate during the incubation period to hatching.

Progeny of reconditioned kelts, hatchery-return and wild broodstocks were reared at Cobequid and Mersey Fish Culture Stations where records of mortality in each group were maintained by hatchery staff. Most juvenile salmon were reared to smolt size; however, in instances where space was a constraint, yearling parr were released and follow-up comparisons could not be made.

Representative groups of smolts were tagged and released in the headwater tributaries of the LaHave River. No adjustments were made to the tag recapture data for tag loss or non-reporting of tags.

RESULTS AND DISCUSSION

Feeding response was invoked by offering whole smelts or fresh fish chunks. Although a few salmon kelts in Group I began feeding at 4°C in early January, the feeding rate was slow and most did not feed until mid-May. Group II and III salmon kelts reared in the freshwater pond at ambient river temperatures, 0.5-2.5°C, were offered feed through holes in the ice; however, no feeding response was observed from December to mid-May because of cold water. As water temperature increased to 7.5°C or above, and as kelts were exposed to saline water, the feeding response in all groups increased dramatically. Food consumption per kelt was highest in Group I, followed by Group II and III during the first year of rearing.

Although some kelts in all groups continued to feed after being acclimated to freshwater, feeding was arbitrarily discontinued in early October prior to spawning. Kelts that continued to feed in September were presumed to be non-maturing fish.

During the second winter, salmon kelts placed in the freshwater pond at ambient river temperatures, 0.5–2.5°C, did not feed from December to April. Salmon kelts placed in 28 o/oo in the 3 m laboratory tanks at temperatures of 3.5–4.0°C began feeding one month after spawning. Although the feeding rate was well below the summer level, it was four times that observed the first year under simiar salinity and temperature conditions. Salmon kelts in both groups began feeding in early May at temperatures of 4 – 5°C as they were acclimated to summer rearing conditions. Consumption reached 504 g/kelt during May, in contrast to 13 g/kelt during the same period the first year. Although food consumption per kelt was high in both experimental groups, Group I exhibited the higher feeding rate from May to October. By August 31, the feeding rate in both groups decreased sharply, and the majority of kelts ceased feeding by mid-September, presumably in response to the onset of gonadal maturation.

During the first winter of rearing, 1-sea-winter salmon kelts grew slightly more in length and lost less weight when reared in saltwater (28 o/oo) than kelts reared in freshwater (Table 1). A weight loss combined with only a slight increase in fork length from December to April caused a reduction in condition factor in all groups. However, increased feeding activity coincident with warmer rearing temperatures from April to August of the first summer produced increases in both length and weight, resulting in rapid reconditioning in all three experimental groups of fish. At the end of the first year of rearing, T-test statistics and analysis of variance comparing total changes in fork length, weight and condition factors of 1-sea-winter males, females and both sexes combined with rearing regimes indicate significant differences ($p < 0.05$) in growth occurred, especially for females, in the different rearing regimes. Salmon kelts in Group I exhibited the best growth followed by those in Group II; Group III exhibited the slowest growth. Larger growth increments in salmon kelts reared during the summer period in a salinity of 16 o/oo was at least partially attributed to warmer temperatures at this salinity compared to those in saltwater (28 o/oo).

Growth patterns during the second year of rearing simulated the trends evident the first year (Table 2). T-test statistics and analysis of variance comparing growth changes of 1-sea-winter salmon kelts reared in different regimes indicate significant differences ($p < 0.05$) in fork length and weight, especially for females. Salmon kelts in Group I produced significantly larger increments of growth in length and weight compared to those reared under Group II conditions. By the end of the second summer of rearing, salmon kelts in both groups had exhibited rapid growth in length and weight.

Growth characteristics of 2-sea-winter fish were similar to those of 1-sea-winter salmon in both years; however, the number of 2-sea-winter salmon was too small to make conclusive statistical comparisons. Although growth characteristics varied between the groups, all salinities tested were satisfactory for reconditioning salmon kelts.

Survival of salmon kelts during the first year of rearing was high in all groups; combined group survival was 93.1 per cent. Combined group survival during the second year of rearing was 82.7 per cent, and survival in all groups for the complete two-year period was 77 per cent (Table 3). Since a number of the mortalities were caused by stress associated with sampling and spawning, higher survival rates could have been achieved if handling were reduced.

One-sea-winter female salmon kelts in group I exhibited the highest gonadal maturation rate during both the first and second year of rearing. After one year of rearing, 17.9 per cent of the 1-sea-winter female kelts and 40.6 per cent of the one-sea-winter male kelts achieved maturity and spawned. After the second year, 83.3 per cent of the 1-sea-winter female kelts and 96.3 per cent of the 1-sea-winter male kelts matured. Combined totals for salmon kelts regardless of rearing conditions or age at first maturity indicate that 18.4 per cent of all females and 44.1 per cent of all males reached sexual maturity after the first year of rearing. After two years, 86.8 per cent of all females and 96.6 per cent of all males matured (Table 4).

Reconditioned salmon kelts were examined and sorted for spawning in mid-October. Spawning occurred from mid-November to mid-December, resulting in a deposition of 278,363 eggs. Salmon kelts with a mean fork length of 68.4 cm (+/- 5.13) and mean weight of 3.380 kg produced 7,261 eggs (+/- 1,811) per fish with an egg diameter of 5.70 mm (+/- 0.321) and 2,262 eggs.kg^{-1} (+/- 963). Egg coloration and size was comparable and fecundity was slightly higher than that reported for wild salmon eggs in several rivers (Baum and Meister, 1971; Cutting and Gray, 1984).

Survival of kelt progeny (73.5 per cent) was slightly lower than hatchery-return progeny (89.2 per cent) from the green egg to the alevin stage (Table 5). When the survival of kelt and hatchery-return progeny were compared prior to release as 1+ smolts, kelt progeny had higher survival rates than hatchery-return progeny ($p < 0.01$) and overall survival was comparable to green egg to smolt survival rates normally achieved at Mersey Fish Culture Station.

Although it was difficult to make comparisons between kelt and hatchery-return progeny because of differences in hatchery rearing environmments, smolt age and release dates, an overall evaluation of smolt to adult return was possible. The tag recapture rate of F1 kelt progeny released as tagged 2+ smolts in the LaHave River was not significantly different ($p < 0.01$) from that observed from hatchery-return progeny released as either tagged 1+ large- or medium-grade smolts in 1976 (Table 6) and compared favorably with that reported for other hatchery-reared or wild smolts (Saunders, 1967; Turner, 1975). Finally, the tag recapture rate of F1 progeny from other genetic stocks of reconditioned kelts not reported in this paper ranged from 1.43 per cent to 2.28 per cent (Gray, unpublished data), demonstrating that F1 kelt progeny were as viable as other progeny from hatchery-return or wild broodstocks reared in Maritime hatcheries.

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Table 1. Comparative growth characteristics of Atlantic salmon kelts reared in different salinities during the first year. Numbers in parenthesis are standard deviations of the mean.

	Sea-winter age		Fork length (cm)[1]				Weight (kg)[2]				Condition factor[3]			
Rearing conditions	at first maturity	n	FL1 Mean (SD)	FL2 Mean (SD)	FL3 Mean (SD)	ΔFL Mean (SD)	WT1 Mean (SD)	WT2 Mean (SD)	WT3 Mean (SD)	Δ WT Mean (SD)	K1 Mean (SD)	K2 Mean (SD)	K3 Mean (SD)	Δ K Mean (SD)
28(W1):16(S1)	1SW	14	55.0(3.22)	56.0(2.68)	60.2(3.35)	5.2(1.52)	1.370(0.2731)	1.304(0.2687)	2.411(0.4509)	1.041(0.3575)	0.82(0.097)	0.73(0.070)	1.09(0.093)	0.28(0.128)
	2SW	5	71.2(2.80)	71.3(2.71)	72.9(3.15)	1.7(1.75)	2.801(0.5121)	2.580(0.4617)	3.666(0.9741)	0.865(0.6146)	0.77(0.049)	0.71(0.078)	0.93(0.138)	0.16(0.097)
F(W1):16(S1)	1SW	32	54.4(2.84)	55.1(2.65)	58.0(3.22)	3.6(2.21)	1.302(0.3031)	1.213(0.2456)	2.135(0.4722)	0.833(0.4089)	0.80(0.147)	0.72(0.082)	1.08(0.141)	0.28(0.181)
	2SW	3	71.3(2.89)	71.5(3.04)	72.7(1.04)	1.3(1.89)	2.587(0.4937)	2.362(0.5276)	2.972(0.7001)	0.385(1.1912)	0.71(0.062)	0.64(0.082)	0.78(0.220)	0.07(0.276)
F(W1):28(S1)	1SW	24	55.3(2.96)	56.0(3.01)	58.1(2.83)	2.9(2.12)	1.366(0.2943)	1.281(0.2422)	1.940(0.5038)	0.574(0.4659)	0.80(0.112)	0.72(0.083)	0.97(0.182)	0.17(0.184)
	2SW	3	71.8(3.51)	71.8(3.51)	73.2(4.04)	1.3(0.58)	2.556(1.0370)	2.268(0.7982)	3.573(1.548)	1.017(0.5476)	0.67(0.193)	0.60(0.143)	0.88(0.251)	0.21(0.070)

[1] FL1 = fork length Dec. 1973; FL2 = fork length April 1974; FL3 = fork length August 1974; Δ FL = FL3-FL1.

[2] WT1 = weight Dec. 1973; WT2 = weight April 1974; WT3 = weight August 1974; Δ WT = WT3-WT1.

[3] K1 = condition factor Dec. 1973; K2 = condition factor April 1974; K3 = condition factor August 1974; Δ K = K3-K1.

Table 2. Comparative growth characteristics of Atlantic salmon kelts reared in different salinities during the second year. Numbers in parenthesis are standard deviations of the mean.

			Fork length (cm)[1]				Weight (kg)[2]				Condition factor[3]			
Rearing conditions	Sea-winter age at first maturity	n	FL4 Mean (SD)	FL5 Mean (SD)	FL6 Mean (SD)	Δ FL Mean (SD)	WT4 Mean (SD)	WT5 Mean (SD)	WT6 Mean (SD)	Δ WT Mean (SD)	K4 Mean (SD)	K5 Mean (SD)	K6 Mean (SD)	Δ K Mean (SD)
28(W2):16(S2)	1SW	11	59.2(2.24)	61.1(3.32)	68.1(3.32)	9.0(2.37)	2.022(0.4359)	1.909(0.3970)	3.214(0.5065)	1.191(0.5476)	0.97(0.218)	0.82(0.069)	1.02(0.171)	0.04(0.264)
	2SW	2	73.5(1.41)	73.5(1.41)	74.7(1.06)	1.2(0.35)	3.482(0.4985)	2.925(0.2241)	3.214(0.5065)	1.191(0.5476)	0.97(0.218)	0.82(0.069)	1.02(0.171)	0.04(0.264)
F(W2):16(S2)	1SW	35	60.8(3.13)	61.4(3.38)	66.3(4.87)	5.5(2.97)	2.264(0.5077)	2.104(0.4978)	3.111(0.7246)	0.846(0.5385)	1.00(0.146)	0.90(0.140)	1.06(0.160)	0.06(0.192)
	2SW	7	73.2(5.63)	73.4(5.13)	76.7(5.82)	3.5(2.38)	3.036(0.8856)	2.642(0.7512)	4.221(1.1499)	1.184(0.8372)	0.78(0.216)	0.67(0.164)	0.92(0.161)	0.14(0.179)

[1] FL4 = fork length Dec. 1974; FL5 = fork length April 1975; FL6 = fork length October 1975; Δ FL = FL6-FL4.

[2] WT4 = weight Dec. 1974; WT5 = weight April 1975; WT6 = weight October 1975; Δ WT = WT6-WT4.

[3] K4 = condition factor Dec. 1974; K5 = condition factor April 1975; K6 = condition factor October 1975; Δ K = K6-K4.

Table 3. Survival of salmon kelts reared in different salinities over a two-year period. Number of surviving kelts appear in parenthesis.

Group/Age at first maturity	n	First winter	First summer	Year I	n	Second winter	Second summer	Year II
		SURVIVAL[1] (%)						
I								
1SW	15	93.3(14)	100.0(14)	93.3(14)	17	76.5(13)	100.0(13)	76.5(13)
2SW	7	100.0(7)	85.7(6)	85.7(6)	5	60.0(3)	100.0(3)	60.0(3)
II								
1SW	32	100.0(32)	96.9(31)	96.9(31)	51	96.1(49)	89.8(44)	86.3(44)
2SW	3	100.0(3)	100.0(3)	100.0(3)	8	100.0(8)	87.5(7)	87.5(7)
III								
1SW	25	100.0(25)	92.0(23)	92.0(23)				
2SW	5	100.0(5)	80.0(4)	80.0(4)				
Total	87	98.8(86)	94.2(81)	93.1(83)	81	90.1(73)	91.8(67)	82.7(67)

[1] Overall survival for the two-year period was 77.0%.

Table 4. Comparative maturation rates of salmon kelts reared in different salinities over a two-year period. Numbers of mature kelts appear in parenthesis.

Group/ Sex	1-sea-winter				2-sea-winter			
	First year		Second year		First year		Second year	
	n	%	n	%	n	%	n	%
I								
Female	10(3)	30.0	10(9)	90.0	5(0)	0.0	3(3)	100.0
Male	4(1)	25.0	3(3)	100.0	1(1)	100.0	0(0)	
II								
Female	17(3)	17.6	20(16)	80.0	3(1)	33.3	5(5)	100.0
Male	16(8)	50.0	24(23)	95.8	0(0)		2(2)	100.0
III								
Female	12(1)	8.3			2(1)	50.0		
Male	12(4)	33.3			1(1)	100.0		
Combined groups								
Female	39(7)	17.9	30(25)	83.3	10(2)	20.0	8(8)	100.0
Male	32(13)	40.6	27(26)	96.3	2(2)	100.0	2(2)	100.0

Table 5. Survival of Atlantic salmon progeny from reconditioned kelt (RK) and hatchery-return parentage (HR) spawned in 1975 and reared at Mersey Fish Culture Station. Numbers in parenthesis represent % survival from green eggs.

Stock origin	Number of eggs deposited	Survival Number of alevins	Survival Number of 1+ smolts released
LaHave - RK	228,512[1]	167,939 (73.5)	88,706 (38.8)
LaHave - HR	177,011	157,908 (89.2)	51,179 (28.9)

[1] An additional 49,851 kelt eggs were collected, but were used for other research studies.

Table 6. Comparison of tag recapture data between tagged smolt groups from reconditioned kelt (RK) and hatchery-return (HR) parentage released in the LaHave River in 1976.

Stock origin	Stage	Year-class	Rearing location	Release date	Number released	Number of tag recaptures
LaHave - RK	2+ smolt	1973	Cobequid	May 6, 1976	3,994	88 (2.20)
LaHave - HR	1+ smolt (large)	1974	Mersey	April 20, 1976	3,395	90 (2.65)
LaHave - HR	1+ smolt (medium)	1974	Mersey	April 23, 1976	4,573	99 (2.16)

SALMONID BIOTECHNOLOGY

by

Dr. Brian Glebe
Huntsman Marine Laboratory
St. Andrews, New Brunswick

Yesterday, Peter Hjul mentioned the tremendous volume of salmon appearing on the European market -- 56,000 tonnes. He also mentioned the price of salmon, because of these tremendous volumes reaching the market, is falling. I think it's very important for salmon farmers to realize that to maintain their competitiveness in such a market, they require advanced technology. Mr. Hjul also noted that there are genetic programs underway. People are using advanced caging systems and computer technology. And, I believe, biotechnology will have a place in the industry.

Biotechnology can improve productivity and the farmer's ability to compete. It can solve basic biological problems, such as early maturation and poor cold-water tolerance in salmonids. It can improve resistance to disease, and even, perhaps, enhance growth.

I have categorized biotechnology under several headings:

1. **MOLECULAR:** includes recombinent DNA techniques. There is work underway to introduce an antifreeze gene from winter flounder into Atlantic salmon, as well as to perform growth hormone synthesis by bacteria, and also in the use of monoclonal antibody techniques for the production of vaccines, especially for viruses which are very difficult to culture.

2. **CHROMOSOMAL:** includes such techniques as chromosome engineering. These would involve triploidy, manipulating the number of chromosomes from the normal two to multiples of two or three.

3. **SYSTEMS:** includes manipulation of the endocrine system and involves sex reversal, sterilization, and/or stimulation of ovulation in salmonids.

4. **WHOLE ANIMAL:** includes genetic selection, new species, hybridization of various species, and combinations of the aforementioned techniques with hybridization, as in triploid hybrids.

Larger companies involved in salmon culture in southern New Brunswick are employing high-tech hatcheries, rearing systems, and cage-rearing systems. One example is the Sea Farm Canada Packers Hatchery near St. George, New Brunswick. It has a potential capacity of one million smolts. It uses oxygen injection and automatic grading equipment and the latest imported technology. Another example of high-tech rearing is the steel cage systems being used at Ocean Products in Maine, the largest concern on the East Coast. By this spring, they will have 98 Jamex-style cages in place. Unfortunately, biotechnology hasn't kept pace with the developments of these rearing systems. However, various research activities are underway that are trying to keep pace in order to improve the creatures going into these culture situations.

The first is recombinent DNA technology. Within that technology, there has been work to mass produce vaccines through monoclonal antibody production. At present, it is possible to clone genes which code for particular antigens associated with, for example, viruses. By using culture bacteria and harvesting the antigen, a vaccine can be produced. This holds potential for the production of vaccines for the aquaculture industry to be used against ubiquitous diseases such as IPN. Gene coding for the antigen associated with the IPN virus could be cloned in _E. coli_ using a plasmid carrier. The _E. coli_ is grown and the antigen can be concentrated and used as a vaccine.

At present, the growth hormone is being produced by biotechnology. Researchers have incorporated the growth hormone gene into bacteria by using plasma carriers allowing the growth hormone to be harvested. Experimentally, it has been injected into fish to promote growth. Within the past three years, growth hormone genes from the rat have been introduced into mice embryos, along with a promoter, and this has resulted in enhanced growth of mice. The potential is there for incorporating foreign genes for growth hormone production into fish, so that these genes are then passed from one generation to the next.

Here in the Maritimes, because we have such cold water, there is work underway to incorporate the winter flounder antifreeze gene into the Atlantic salmon genome. This involves the cloning of the gene and the injection of the winter flounder antifreeze gene into recently fertilized Atlantic salmon eggs. A micropipet is used to inject many millions of copies of the gene into each salmon egg. The hope is that it will be incorporated into the genome and passed on from generation to generation. I think it's a very distinct possibility.

Already, spinoff technology has arisen from this type of work, in that, during this procedure, eggs are fertilized in a balanced salt solution. The sperm lodges in the micropyle, but no cleavage occurs until the ionic balance of the salt solution is changed. Essentially, you ship eggs in this state with no cleavage or activation occurring. At the receiving end, water is added and the eggs immediately start dividing. It's a simple way to ship eggs, and it has developed out of this technology.

If you look at the higher order genetics work being done, you find that it involves using wild populations of fish to produce the best seedling individuals possible for aquaculture.

Basically there are three different techniques:

1. **GENETIC SELECTION** involves selecting the best individuals and concentrating desirable genes in those populations. These genes are passed on to subsequent generations and you end up with improved fish for aquaculture. They may be later-maturing, faster-growing and in selected populations, you can also do chromosome engineering techniques, such as sex reversal, for enhanced performance.

2. **CHROMOSOME ENGINEERING** can be achieved by manipulating the gene or chromosome numbers, and by the introduction of triploidy, for example, by using heat shock to produce infertile triploid hybrids.

3. **SEX REVERSAL** uses exogenous hormones to control the sex. For example, females tend to mature later than males so, if you produce all-female populations, you produce a group that is more desirable for aquaculture. Early maturation is associated with poor carcass quality and slower growth.

The basis of genetic selection is variation in traits that are genetically inheritable. Meat color in rainbow trout is one example. It varies between different family groups. So you select individuals from the best families and breed them. Their progeny should produce better flesh quality. This type of work is going on at SRL in southern New Brunswick, where they are looking at manipulating other traits, such as age at maturity and growth for sea ranching and cage culture. If you take a small component of that genetic program and look at it on a time scale, you see that it takes a long time to produce genetic gains because of the four years it takes for each generation of the Atlantic salmon to mature. It's a very long and tedious procedure, although the gains are significant.

More immediate results can be obtained by sex reversal. You can feed male and female sex steroids in the diet of juvenile fish. For example, feed methyl testosterone, a male steroid, to produce an almost 100 per cent male population. Feeding esterdiol, a female sex steroid, will result in an almost 100 per cent female population. The control is a one-to-one ratio and these other ratios are skewed depending on the type of sex steroid used.

Sex-changed female fish from those populations will produce normal viable milt. That milt will be all X type. (The sex-determining mechanism in salmonids is the same as for humans in that the male has the XY type sex chromosome and the female has the XX type chromosome pair). So, the sperm from a female fish will be the X type. If the eggs are fertilized by a normal female (all XX type) with the female which is genetically a female, but phenotypically a male, you get 100 per cent female populations. These techniques are being used on a fairly large scale in British Columbia.

There are some precautions which should be associated with using these techniques. For example, chinook salmon were stocked in sea cages on the West Coast. There are different types, including natural fish, which have no hormone manipulation, as well as sterile fish, which were fed overdoses of a methyl testosterone diet (20,000 introduced into the seacages), and feminized fish, that were treated with esterdiol to produce all female populations (237,000 were put into seacages). These fish are being harvested this year. These techniques are being used on a commercial scale, although it's called experimental. I would advise caution because, quite often, the public associates the use of hormones, especially steroids, with a threat to public health because of the problems with anabolic steroids that occurred in cattle some time ago.

In other parts of the world, genetic engineering techniques are being commercialized. There are hatcheries in the U.K. that are producing monosex female eggs and triploid monosex eggs. The benefits are no male gonad development in monosex female populations.

Extending these techniques one step further, you can produce triploid monosex populations. You take monosex eggs and, during the process of fertilization, expose them to a physical or chemical shock, such as high pressure, temperature shock, or chemical shock, (for example, by exposing them to nitrous oxide or laughing gas, a very powerful triploidy inducer) to produce retention of an extra chromosome. You then have a triploid having three sets of chromosomes, whereas a normal fertilized egg would only have two. These triploids offer some advantages in that triploid females tend to be sterile. Unfortunately, triploid males don't. This technique should be used, therefore, with monosex female populations.

If you look at the different salmonids that are being cultured on the East Coast, whether for enhancement or for aquaculture, the list would include Arctic char, rainbow trout, brook trout, lake trout, and land-locked and sea-run salmon. Of these species, the rainbow trout and the Atlantic salmon are now being cultured commercially. One fish that I think provides some promise for commercial enterprise is the Arctic char. An anadromous char will be introduced into P.E.I. this year. The Arctic char, from work that has been done in St. Andrews and in Winnepeg, has been shown to be a very hardy fish that can be grown in higher stocking densities than even rainbow trout. Its growth at low temperatures is much faster than rainbows or Atlantic salmon. The only drawback is that they have very poor salinity tolerance. We placed them in seawater cages and tolerance at 30 ^{o}/oo salt has not been good. If you're down around 26 ^{o}/oo, there is no problem, but that is a very narrow margin for error. We've evaluated the salinity tolerance for three different populations, one from the Northwest Territories, which is an anadromous population, one from Labrador, which is also anadromous, and a land-locked population from New Brunswick, one of the relic populations left behind from the ice-age. We found that the Labrador char did very well in seawater when compared with the Northwest Territories char, but not quite as well as the Atlantic salmon. The Northwest Territories char could not survive the full-strength salinities of the Bay of Fundy. So this population, at present, seems to have some potential for seawater growout.

By combining genes from a fast-growing species like the Arctic char with Atlantic salmon in a hybrid, you can combine traits that are expressed by both types of populations or both types of species. This is what we have done. We've taken eggs from Atlantic salmon and fertilized them with sperm from Arctic char, to produce a hybrid. We carried it one step further in that these hybrid eggs were heat-shocked and also nitrous oxide-shocked to produce triploids, which means that the triplid hybrid is two-thirds Atlantic salmon and one-third Arctic char because it has two sets of chromosomes from the female parent, the Atlantic salmon, and only one set from the male parent. Concerning growth performances of these various groups, including pure salmon diploids, pure salmon triploids, hybrid diploids, and hybrid triploids, we find that the hybrids involving char chromosome inclusions produced, by far, the best growth. After 60 weeks, they were approximately twice the weight of the pure Atlantic salmon and that's the influence of the char genes. The reason for doing a triploidy is to produce a fish that is sterile and, again, the advantage is that sterile fish do not divert energy to gonad development and will grow to a much larger size.

Those fish have been introduced into seawater cages and we know now that the triploid hybrids do much better in seawater than the pure Arctic char. So I think there's potential for genetically manipulating the stocks to suit your local environments.

At the systems level, you can manipulate the endocrine mechanisms of fish. A student at my lab right now is using lutenizing releasing hormone, a mammalian analog, to stimulate ovulation in Atlantic salmon. The industry in southern New Brunswick has a minor problem in that spawning tends to be protracted; it begins around the end of October and carries on, in some cases, until December. By using analogs of mammalian hormones, which are inserted via the egg pore as a pellet, we can stimulate natural gonadotrophin production from the pituitary which, in turn, causes the egg to develop at a faster rate, synchronizing and accelerating spawning. The consequences are, at larger farms, that within a week to ten days after hormone treatment, all the fish have ovulated, whereas in those which weren't treated, spawning takes at least a month. This means less handling of the fish, which is better for fish health, and less work for the farmer, who otherwise has to constantly overhaul his fish in order to check for ovulated females because you can't let females go very long after ovulation or the egg quality deteriorates considerably. These techniques can also be combined with photoperiod. LH-RH treatments in combination with advanced photoperiods can accelerate spawning into October and reduce its duration. Those fish on natural photoperiods without any hormone treatment started spawning sometime in October and went until the middle of December.

There are techniques available now for farmers to sex their fish. I think this is very important for the salmonid industry in New Brunswick in that, traditionally, fish farmers set aside some of their production fish as brood stock. They couldn't sex them and they didn't know if a given fish was going to mature the next year. By using blood sampling techniques, which are fairly hard on the fish, at the time of separation, you can determine sex and whether they're going to mature in a given year. This is done by looking at the vitellogenin levels, the egg protein constituents in the blood. As the eggs are developing, vitellogenin levels rise and can be detected easily, using immunological techniques. You just produce antiserum to vitellogenin, which you put in the centre well on a plain agar plate. In the outer well, you put a blood serum sample from each individual fish. If you get a precipitate in the well, that indicates that it is a female and, if you get a white band formed in between the antibody which is in the centre well and the vitellogenin osmosing from the outer well, that precipitate indicates agglutination and the presence of vitellogenin, indicative of a maturing female salmon. Using this method, you can determine the sex of the females when their ovaries are at the infantile stage and, if they're not going to develop that year, you can send those fish to market and effectively manage your brood stock population.

There are other techniques being developed on the West Coast where, by using enzyme-linked color reaction, and by taking a swab of the mucous of the fish, you can detect the presence of those egg proteins as metabolites in the mucous in order to identify the sex of your fish very early in development. But this has been done with limited success so far.

CONCLUSION

Canadians are world leaders in developing biotechnology. Unfortunately, we generally tend to fall behind when it comes to applying this technology or commercializing it. I think that is why these workshops are so very important. They are intended to commercialize techniques and to increase the competitiveness of the individuals involved in aquaculture. I think they are a step in the right direction.

MARKETING AND PROMOTION

PANEL

SPEAKER	AFFILIATION
George W. Wolfe	Jail Island Salmon Ltd.
Robert Robillard	Waldman's Fish Company
William L. Mockbee	WLM Consultants

George W. (Skip) Wolfe
Jail Island Salmon Ltd.
St. George, New Brunswick

I'm a fish farmer, not a salesman, so I want to give you an idea of what's been happening in market development for fish farms, specifically, salmon and trout farms in southern New Brunswick.

In 1981, there were two fish farms operating in southern New Brunswick, the Marine Products operation and John L'Aventure's farm on Grand Manan. The provincial Department of Fisheries sponsored a trip to Norway for those of us who were just getting into fish farming to get a good look at what was going on there. We were totally amazed.

It was clear to us that we should develop as quickly as possible. The Norwegians were doing it and we felt that if we were going to get into the marketplace, and have any presence at all, we should develop quickly. Second, and perhaps the salient impression we formed, was that the Norwegians produce nothing but quality. They don't settle for anything less than first qrade in the fish they produce. Third, we came away with the conviction that it is possible to grow fish. It's not something so totally foreign that nobody can understand it. Lastly, we developed the very clear understanding (at least some of us did) that we should market as a group. Why? There is strength in numbers. There's economy to be achieved. However, it was not a unanimous feeling at that point, partly due to the fact that people who are independent, stubborn, survivors, or people who are going to get in there and compete, don't like to give up their independence. That's not peculiar to fish farmers. It's peculiar to anyone who's willing to work on his own to achieve something. He doesn't want to give up his independence.

Anyway, we returned and went to work establishing fish farms and trying to grow fish. Some of us, Jail Island for example, had terrible luck. We put in 1,000 fish the first year and we were able to bring only 75 to market. We did that individually.

For a couple of years, members of that original group marketed their fish as individuals but, as you can imagine, the marketplace ate us up. You go into the marketplace and growers get played off against each other. That realization gradually prevaded the group.

In 1984, we, in a very loose organization, a gentlemen's agreement, agreed to market our fish through one desk. There was nothing binding or contractional. It seemed to make more sense for one of us to take the orders on the basis of our total projected production. It worked because we all realized that it was to our benefit.

That market season worked so well we realized we had to give the group some formal structure. We sat down with the provincial government (Commerce and Technology) and, with its help set up the group which now has the name, ATLANTIC SILVER, a limited company. It's totally owned by the fish farmers in southern New Brunswick, and this year and last year it marketed all salmon produced in southern New Brunswick. Next year, we hope to do the same thing.

This type of marketing approach unifies the marketplace and, if there's one important benefit, that's it. It brings all the fish through one desk, and it achieves certain economies, obviously, because not everybody has to go out and design his own packaging. It finances its operations just like any fish broker would, by taking a percentage off the top, with the profits returned to the people who produced the fish. Production by Atlantic Silver for the 1984/85 season was almost 300 tonnes.

This year, we hope to be in the 500-tonne range and, in the next market year, we hope for close to 1,200 tonnes. So we're growing, though not as fast as our European competition. In fact, I've been told that we are not even maintaining our share of the market. That's a function of a lack of seed stock, and I hope it will change in the future.

The concerns which resulted in the creation of Atlantic Silver included the desire to compete with Norway and Scotland. At that point, we weren't really aware of what was going on in the Faroe Islands. We realized that we had to have uniform quality and the only way to do that was to bring everything through one central agency. We also realized that, in order to make the thing work, we needed co-operation among members to police themselves, to set standards and to adhere to them. That took some hard-nosed discussion, but the realization that we were competing with producers known for nothing but quality made the point. So that's what we've been doing, producing a quality product and getting it to the marketplace effectively.

Robert Robillard
Provigo/Waldman Fish Company
Montreal, Quebec

RAINBOW TROUT (for the Quebec trade)

Rainbow trout is a well-known product, having been on the market for a number of years. At one time, trout growers were practically "a dime a dozen".

The more serious trout farmers are still around and they are thriving; the others cut prices. What is the magic behind the success of the ones who lasted? Flesh colour, for the most part, coupled with quality and reliability. It is important that sales volumes remain constant, and that there be limited fresh imports from Idaho.

ATLANTIC SALMON TROUT

Trout of this type is a relatively recent arrival on the market. It is raised in seawater. We were happy to help out last fall when a serious grower approached us to help introduce his product. Immediately, this trout enjoyed an excellent level of acceptance at both the wholesale and retail levels.

Because its introduction has been so recent, the impact of deep-pink-fleshed trout on the market is rather difficult to appraise. It remains, in part, for us to ascertain what other fish it will replace on restaurant menus and whether it will earn a permanent niche there. Also to be determined is whether the retail customer will remain faithful. Volume may remain constant, although limited, because the trout is relatively unknown to a majority of seafood lovers, and it is relatively expensive at the retail level.

ATLANTIC SALMON

Quebec's first legal experience with farmed Atlantic salmon occurred a couple of years ago with Mow salmon from Norway. A year or so ago, Canada also allowed one salmon farm to ship cultivated salmon to Canada from Scotland. The market was, of course, ripe for these newcomers. Quebec has always been an excellent market for fresh salmon, Atlantic salmon especially.

So it was to no one's surprise that domestic farm-raised salmon was well received. It must be pointed out, however, that most of Waldman's sales volume is at the wholesale level (the hotel and restaurant trade), although the retail counters do some business. This means that volume is relatively limited because of the price factor. But it is constant.

WHAT IS IN THE FUTURE?

One can only forecast good things for Canadian farm-raised Atlantic salmon, as long as those involved maintain quality. Every effort must be made to maintain the respect people have for this product, in order to increase sales.

Keep in mind that Norway is forecasting an increase of about 15,000 tonnes this year -- 55,000 tonnes compared to 40,000 tonnes last year. And Scotland and Ireland are forecasting imposing figures for 1987. And Canada is also talking about increased production for 1987.

Let's not forget British Columbia. Although it may be a little behind Atlantic salmon growers, it has been shipping several thousand pounds of chinook and coho each year, for the past couple of years. Although B.C. salmon are still small, this will change. It is only fair to assume that, in the near future, B.C. will start making headway and make its presence felt on the market with larger salmon.

PROMOTION

Provigo/Waldman can only do so much. The recent acquisition by Provigo of Pecheries St. Laurent will definitely add clout to the distribution of fish and seafoods in La Belle Province. But our combined efforts will be nil unless we have your support.

Have you told the public of your existence and of the strict quality control you impose upon yourselves before you send your product to market?

I say to you, in all sincerity, promote now. You must keep promoting. Find people who have ways of getting interviews and articles in food-related magazines. There are publications oriented toward the restaurant and hotel trade. Use them. All dailies have at least one food section every week. Endeavour to make your salmon appear in one or more of these so consumers will be aware of the year-round availability of "fresh *Salmo salar*".

William Lee Mockbee
WLM Consultants
St. Andrews, New Brunswick

My presentation concerns marketing, advertising and promotion. There are only six important phases in poor advertising, marketing and promotion:

1. ENTHUSIAM!

...team spirit;
...we will win the customer over;
...we have the best marketing schemes;
...we have the best promotion;
...we are the best!

2. DISILLUSIONMENT

...someone else has a better project;
...someone else has better marketing;
...someone else has better promotion;
...therefore, someone else has a better product than we do!

3. PANIC

...why didn't we cover all our bases?
...why didn't we check the competition?
...why didn't we pre-test our product line?
...why didn't we anticipate a better product?
...what will we do - where will we go - what must be our next step?

4. SEARCH FOR THE GUILTY

...the fault is not mine;
...the fault is someone else's;
...the guilty person will be found;
...I must blame someone else for something I possibly failed to do!

5. PUNISHMENT OF THE INNOCENT

...the brand manager must be found guilty -- all he did was warn me about the competition;
...the product manager must be found guilty -- all she did was warn me about a poor marketing plan;
...the production supervisor must be guilty -- all he did was point out that our market pre-testing was shallow;
...the group coordinators must be found guilty -- all they did was warn me about increased overseas and inter-provincial competition.

6. REWARD FOR THE NON-PARTICIPANT

...Joe had nothing to do with this project -- that deserves my vote;
...Sally was not even involved in studying the competition, so I will reward her for her competitive ability;
...Mark was not on the production line for this one -- he deserves an award;
...Certainly, I deserve an award -- after all, in reviewing the facts, I wasn't involved in any aspect of the project -- period.

This scenario is very true because, sad to relate, it is something that we all have gone through, whether working for ourselves or for someone else.

Positioning of product is the most important advantage you can have. And fish farmers have to worry about positioning product, how it will represent itself and how it will be sold. Do you know your competition? We have all heard about increased competition, not just increased production. After all, you have distinct advantages here.

I would like to quote from an article that appeared in the <u>Night River</u> magazine within the last month: "The North American public has an insatiable desire to spend dollars for quality products and quality food... including salmon, caviar and other luxury items."

Like it or not, and with no comment on the political implications, we are quickly developing into two classes in the Western democracies, those who have and those who have not. And those who have are spending discretionary income faster than ever before.

It is important to know your competition. The competiton is not only salmon. Competition is among product buyers, the consumers. If your estimates and forecasts are reached, the challenge is going to be intense, not only because of the salmon, but because it's a luxury item that the public perceives to be expensive. Perception is what I deal in. You give me a product and I create an illusion or perception based on one key word -- **QUALITY.** The quality of the product is the motivator for people to spend their discretionary dollars, today and tomorrow. The North American consumer is ready to risk those discretionary dollars for gratification and satisfaction today. But an early commitment to quality is important. I cannot even begin to understand some of the medical and physiological problems you have in raising your product, but one thing has been crystal clear to me in every one of these sessions -- the zeal you possess for quality -- and quality will win out! Will the consumer pay for quality? Uncategorically, yes.

The next thing we must learn is flexibility. Learn to develop secondary markets for your product. Learn to expand into those areas where risk-taking is prevalent, but also where you can see the light at the end of the tunnel. When I hear what you people are involved in for a living, there's no way I would do that. Advertising is crazy enough. You people are the greatest risk-takers in the world. You should be proud because you have been willing to make a commitment early and you are certainly flexible in what you are doing.

Meat consumption in the United States has dropped some 45 pounds per person in the past 15 years. Think about the people who have been talking to you over the past couple of days, the attractiveness of the way fish can be served, and the doors that can be opened. You can go out and explain your product to advertisers and let us take it into the marketplace and offer it as a nutritional alternative. The health industry is exploding, as evidenced by the number of health magazines on the market today. People are talking about diet, and they are talking about non-meat items for a sound diet.

Now, let me give you a couple of tips on doing your own advertising:

COPY ELEMENTS

1. THE HEADLINE

How can you sell a product without giving people a headline? You have to tell them what the ad is all about.

2. STRONG COPY AND LAYOUT

3. PICTURE

Whether it is verbal or written, words create pictures. So, put a picture in to tell people what you are talking about.

4. TEXT

You need a headline or a picture, but you also need to describe the product. So, text or copy is important.

5. WHERE TO BUY IT

Better than half of the local advertising in broadcasting and newspapers today fails to give proper directions or information on where to buy the product.

Put these together and you have a successful ad. Again, this works whether it's radio, television, newspapers, magazines, pamphlets, brochures, letterheads, or whatever. There is nothing you can do in your advertising, marketing or promotion that's any simpler, and it works every time.

Think about what you have learned, not from me, but from your own experiences, including quality, headline, picture, descriptive copy, and where to buy it.

WHY DO SOME PRODUCTS SELL SO MUCH BETTER THAN OTHER PRODUCTS?

This is because of the fact that quality wins out. When you tell people you have a quality product, you show them a quality product, they taste a quality product, then they will continue to buy a quality product, your quality product.

RAPPORTAGE
SALMONID CULTURE

by

Frank McKinney

What emerged "loud and clear" from the Salmonid Sessions was the need for a deliberate approach to development by those in fish farming and by those contemplating a move into the industry. Each facet of this approach has implications at the policy, program and/or project level for the Department of Fisheries and Oceans, and some bear directly on the mandate of the Atlantic Fisheries Development Program.

Success in fish farming, regardless of species, requires the best quality smolts, top-grade infrastructure and dedicated manpower and management. Obviously, the assurance of genetically approved disease-free seed stock is an area of prime concern to the scientific component of the department. Its involvement will continue to include providing sound feed stock, detecting and treating fish health problems, and controlling environmental factors affecting aquaculture.

Of particular interest to Atlantic Fisheries Development, however, is the continuing need to investigate new markets, new products, new equipment and new technology involved in fish farming. A great opportunity also exists in disseminating industrial intelligence to producers throughout the Atlantic provinces. By sponsoring conferences and workshops such as this, the Development Branch can continue to bring together all participants -- growers, marketers, equipment suppliers, and scientific personnel -- to exchange ideas, plans, and strategies.

Specifically, technological development must include:

Increased Hatchery Productivity

- designing and evaluating equipment to supply and circulate water;

- tank design to increase load capacity (including tank shapes, water circulation systems, filtration systems, etc.)

- upgrading growing and harvesting methods and techniques, using innovations developed in Canada and abroad.

Over-wintering Techniques and Technologies

(and related R & D)

Shore-based Tanks versus Sea Cage Technology

- analysis of the economics of each;
- escapement considerations;
- infrastructure technology; and
- investigation of alternate species (e.g. eels, trout, etc.).

This type of direct input from industry is invaluable to policy-makers as they formulate plans to take aquaculture into the 1990's.

NON-SALMONID CULTURES

NON-SALMONID CULTURES

by
Peter Hjul
Editorial Director, Fish Farming International
London, England

SUMMARY

Despite their impressive development in the past decade, farmed salmonids make up only about 4 per cent of world aquaculture production. But most of the species in aquatic farming -- e.g. carps, tilapia, mullet, prawns and various seaweeds -- are of little interest to Atlantic Canada. This leaves a relatively small number of fish suitable for cold and temperate regions. Some of these have been under development for farming for many years, and only a very small number are immediate prospects for commercial operations. Progress on the marine flatfish and cod and, in Europe and Japan, on red sea bass and sea bream, should eventually reduce the heavy dependence of northern farmers on salmonids, and on the long-established cultures of mussels and oysters.

With all due respect to the recent considerable achievements in salmonid culture, let me remind you that the vast bulk of farm output is still made up of various carps, milkfish, mullets, yellowtails, eels, tilapia and other species.

Salmon may be spectacular, and trout steady, in the impressive growth of the aquaculture industry, but neither species is dominant. In the long run, the work being done now on prawns, cod, sea bream, sea bass, or mussels may contribute as much to establishing fish farming as a major world supplier of seafoods.

To those who ask why it has taken 15 years to bring turbot to full commercial production, why we are only now moving to the later hatchery stages in halibut, or why the sole is still not a viable commercial farm fish after more than 20 years of work, I recommend the comments in a major paper on Developments in Aquaculture in Europe, prepared for a meeting last year organized by the Food and Agriculture Organisation (FAO). The four authors said in part:

> "While aquaculture is now one of the fastest growing branches of the food production industry, compared to agriculture, its technologies are fairly new, involving considerable risk. People tend to go too fast from experimental conditions to commercial operation. The biology of most species is not well known, and the rearing techniques used are in the beginning of their development. But, more importantly, marketing and other commercial factors have generally been given too little attention, and many failures have resulted from an attempt to go into production too quickly. Too large a jump is frequently taken from laboratory results to commercial operation."

In the 1960s and early 1970s, marine research in Europe focused on the Dover sole, plaice and turbot, all flatfish with a ready sale in the markets. Leading this work were scientists in the UK fisheries laboratories. They collaborated with the British White Fish Authority, which later took over most of the projects, concentrating them in its on-growing site in natural waters at Ardtoe in western Scotland, and in warm-water tanks at the Hunterston nuclear power station. There, warm water from the power station was used to raise temperatures in the fish tanks 5 to 10°C above ambient, which helped to speed growth.

Although, technically, plaice showed the most early promise, it was eventually dropped from the program. It was the cheapest of the three species on the market and it was believed the price would not cover the cost of farming. However, when I visited the new aquaculture centre set up by Sintef in Trondheim recently, I was intrigued to see that plaice was again one of the species under study. Perhaps advances in our ability to farm fish cheaply may bring it back into contention.

Sole never did quite made it. While it can be hatched and raised satisfactorily at the nursery stage, and while it is high-priced and delectable, it is not a shoaling fish and appears not to adjust well to intensive culture.

But the turbot (*Scophthalmus maximus*) has been patiently developed into a viable farm fish. One reason for the persistence of the turbot farmers, of course, is strong market appeal. The North Sea catch, for example, has declined to less than a thousand tons a year. Prices are now around $18 to $20 a kilo for good quality, large fish. From preliminary work some 15 years ago, growing wild juvenile turbot, pilot-scale projects have been set up in Wales and at Hunterston. Early work concentrated on broodwork management, rearing larvae and juveniles, and on feed evaluation.

Whereas sole have to be allowed to spawn naturally, turbot can be stripped of eggs and milt when ripe, so production can be planned. It was also soon learned that relatively slow growing fish in the wild can be brought to market size much faster in temperatures between 13 and 17°C.

The Welsh project, run by the Shearwater company, was later moved to the west coast of France, south of La Rochelle, where it is being continued by a company in the Norwegian Sea Farm group. The incentive to move was the warmer water to speed turbot on-growing. Sea bass, *Dicentrarchus labrax*, and the gilthead sea bream, *Sparus auratus*, also thrive in similar water conditions, and work on these fish has gone well.

The farm in France which I mentioned supplied 10,000 turbot juveniles last year, but it has made such good progress in producing quality sea bream and bass juveniles that its output in 1986 was 300,000 of each of these species. This year, it expects to supply 800,000 bream and 200,000 bass. Meanwhile, it has moved its turbot hatching and nursery growing facility further north to a hatchery it has leased (along with four other companies) in Brittany. This will provide about 80,000 juveniles in 1987, with plans for increasing that 200 to 300 per cent in the future. This producer also on-grows turbot and produced about 50 tons in 1986. The fish sells well in the fastidious French market, and is fully competitive in taste and texture with wild turbot.

Although hatchery survival rates from egg to young fish for on-growing is still low, producers are working on diets to improve nutrition and other factors to reduce early mortality. They will need to persevere if they are to meet what seems to be rapidly increasing demand for fish, particularly from the northwest coast of Spain, where there are already six or seven on-growing farms, and others are planned.

Another Norwegian-backed company, Golden Sea Produce, developed out of the Hunterston project. It is now taking part in a joint venture with a Spanish company. It estimates that in 1986 it supplied probably half the 400,000 turbot juveniles that were sold for on-growing in Europe. These come from its large hatchery at Hunterston, where it has also been on-growing turbot in cages with salmon.

Like the Ferme Marine project in France, GSP also handles bream and bass, confident that these could become the most successful of the marine fish on European farms. Both species are similar to fish already farmed on a large-scale in Japan. There, the sea bream yields about 23,000 to 30,000 tons a year. In fact, a big farm project in Zadar in Yugoslavia has caused some consternation among European hatcheries by importing bream eggs from Japan. But it is also hatching and raising its own stock of sea bass.

At a meeting organized by the FAO in December, Mediterranean fish farming countries estimted their 1986 harvest of these two species at around 4,000 tons, and they expect this to increase to 18,000 tons by 1992. GSP estimtes that hatcheries in Europe produced four million sea bream and six million sea bass juveniles in 1986. These are high-priced fish much prized in Southern European markets. Like most captured species brought into farming, their prices are still based on availability from fish capture. This will change as supply improves, and the marketplace may one day be the only limit to expansion.

Unfortunately, the same cannot be said of the halibut, which has become a prime target for farming. Cultured studies of this valued food fish actually go back more than 50 years to experiments in Trondheim. Other work has been done on the Pacific halibut.

About 1973, I saw large halibut held for breeding in tanks at the Lowestoft Marine Laboratory. The fish is known to grow fast in cold waters but the problem has been to get the young turbot to a stage where they can be on-grown. The Lowestoft fish matured and produced eggs which were fertilized and hatched. But for two years in succession the larvae failed to grow out of the very early yolk-sac stage.

Commenting on this, the research worker in charge of aquaculture at Lowestoft, Dr. Colin Purdom, said:

> "Halibut presents so many problems that prospects of it becoming a fish for ordinary fish farmers are extremely remote. It may be that it would be possible to get good survival by maintaining the fry in special facilities, such as pressure vessels, but that is not practical in commercial farming. In the wild, halibut spawn at very great depths (around 1,000 metres) and the eggs exist suspended in mid-water which is cold, still and dark. If we have to try and replicate those conditions on the surface, it is going to cost an awful lot of money."

Norwegian researchers began to run into the same problem after they began work to bring the halibut into farming. They started their investigations in 1974, and, by 1980, had managed to grow only two larvae to a size of 30 mm.

By 1982/83, a broodstock had been established at the Austevoll research station south of Bergen. The first eggs were stripped in February, 1983. Since then, two other broodstocks have been established with five institutions participating. The block here, as in Lowestoft, was that the larvae simply faded out. Nothing could induce them to feed and grow.

But the Norwegians also sensed, as had Dr. Purdom, that they might need conditions similar to those in the wild. Pressure might be impossible to provide, but they could be given pitch darkness. This was done in five bags or cages shrouded in black PVC and covered at the top. Each cage housed 1,500 larvae and 3.3 per cent survived through metamorphosis and were taken from the cages for on-growing at between 88 and 96 days. There are obviously other problems still to be solved but the Norwegians seem to be confident that they have cleared the main obstacle, and halibut farming is now being developed to the commercial stage.

One point that is often made about the culture of marine fish is that the eggs and larval stages are very small and delicate. For decades this was thought to be a nearly impossible obstacle to the farming of cod, which produces millions of minute offspring of which only a small number survive. But this fecund and widely-caught fish has been taken surprisingly quickly to the fringes of viable aquaculture. Last week at the International Food Exhibition in London, a Norwegian company had farmed cod on display. Other companies are also getting involved.

As with halibut, experiments in rearing cod go back a long time. In the Lowestoft laboratory, it was found that cod were easier to rear than turbot, using the same basic techniques. At the Austevoll station, using the same seawater pond that held the halibut cages, a team led by Victor

Oiestad began work in 1980. The aim was to develop intensive culture at the difficult nursery stage, feeding the fry on cultured rotifers or collected zooplankton. The next stage will probably be an extensive pond system, protected from potential predators.

By as early as 1983, the team had achieved high survival rates up to the metamorphosis stage. From then the young fish should have grown with good survival rates. But of 500,000, only 75,000 grew on to 10 cm. The most acute problems were cannibalism, (the fish grew unevenly and the larger preyed on the smaller) and an inefficient capture method for transfer.

The team tackled the cannibalism by getting an even distribution of pelleted particles of food pushed out in the water streams through five propellers installed in the pond. To the fish, the pellets were like moving plankton. An underwater loudspeaker was programmed to give out sound impulses before feeding. This conditioned the fish to associate the sound with the food at a particular location. The same sound was then given out at a trap and pump. Attracted to it, the cod moved obediently to be collected, pumped up, graded and sent into the holding cages or tanks.

When he described the system at a meeting in Trondheim in August, Victor Oeistad said refinements were being introduced. But from 75,000 in 1983, the survival rate had gone up to 120,000 in 1985.

As any fisherman will tell you, however, cod is not scarce. In most years, the catch in the North Atlantic is over two million tons. But the supply fluctuates. At present, quotas have been cut for the North Sea and also here in Canada; Iceland is expecting a good harvest; and Northern Norway will catch a lot during the next few years. So farming costs must be kept as low as possible. Farmers will need to develop as much automation as possible in handling their fish, and as much economy as they can in feeding.

Arctic char is another fish offering considerable promise for aquaculture in Norway. It grows rapidly in cold waters and, for this reason, the strongest R&D interest has been in the far north of the country.

For some years, the University of Tromsoe was given access to research facilities in a hatchery complex run by a private company. This has now been bought from the company, and the Norwegian government has put up an initial $9 million to set up an Aquaculture Research Centre for North Norway. A research team has broodstock and is ready to begin a breeding and on-growing programme from the centre.

Arctic char can grow up to two kilograms in three years. It is a good eating fish, hardy and amenable to farming. One problem is that, like the salmon farmed in Ireland, there is a high incidence of early maturing or grilsing.

The centre also plans to be one of the organizations in Northern Europe to farm the small queen scallop (Chlamys islandica), which is also being vigorously exploited by Norwegian fishing vessels. The market is thought to be large enough to accommodate products from farming, as well as from the capture fishery.

Although carried out on a much smaller scale than in Japan or Taiwan, eel culture is also a well-established in Europe, one which is seen to have considerable prospects for expansion. The present market is for about 25,000 tons of high-quality cultured eels a year, but eel farm supporters say this could be doubled to 50,000 tons.

About 7,000 tons are farmed in extensive systems in southern Europe, but future growth will most likely be in intensive systems using heated water from power station or industry sources, aeration, and recirculation. There has been considerable development of such systems in Denmark where production is forecast to rise to 4,000 tons by 1990. The latest development is on the southern coast of Sweden where a large chemical company is using heated water from its processes in an eel farm which will eventually produce about 100 tons a year.

While some of the figures I have mentioned may seem small against the 120,000 tons or more of farmed Atlantic salmon expected by 1990, or the present European harvest of nearly 190,000 tons of rainbow trout, the culture of non-salmonid species has promise of its own. The long, patient work involved in bringing once-wild fish to the farm has helped create the experience and has attracted and developed the skills that will diversify the aquaculture industry and increase its role as a supplier of variety, as well as of quality, in seafoods.

CLOSING REMARKS

by

Yves Tournois

Director, Atlantic Fisheries Development Branch

Fisheries and Oceans

Ottawa, Ontario

Closing remarks are always hard to fine tune to the appropriate level. Today, it is an almost impossible task! There is no way that my closing remarks can approach the level of excellence demonstrated by the speakers at this Workshop.

I will, therefore, limit my intervention to an expression of appreciation on behalf of the Department, in the Gulf Region and in Ottawa.

I would like to thank Dave Morgan of Holland College and the Organizing Committee for setting the stage which allowed the Workshop to be so successful.

I want to thank the speakers who have shared with us their experience, their knowledge, and their vision of the many facets of an industry which, in the words of Tom Hayes, has "come of age".

I want to thank the moderators who maintained a very tight schedule. They did it with such skill that participants did not lose the opportunity to express their concerns through discussion and comment.

I also want to thank the people behind the scenes. The translators, who were reduced in number because of the storm, performed excellently. The people at the registration desk carried out their responsibilities in an efficient and courteous manner. And finally, I want to thank all participants. This was your Workshop. We provided a spat, but you made it grow. Thank you all very much.

APPENDICES

Appendix A

ATLANTIC AQUACULTURE WORKSHOP
FEBRUARY 9 - 12, 1987

AGENDA

EVENING

MONDAY, FEBRUARY 9, 1987

18:00 - 21:00 Registration
19:00 - 21:00 Reception (Hosted by the P.E.I. Department of Fisheries)

DAY 1

TUESDAY, FEBRUARY 10, 1987 (MORNING SESSION)

08:00 Registration
09:00 Plenary Session
- Welcome
- Opening Remarks

SALMONID CULTURE

Moderator: S. Campbell

09:30 Precis of Salmonid Culture in Europe
- P. Hjul

09:50 A Case History of an Atlantic Salmon Farm
- J. L'Aventure

10:10 **Discussion**
10:20 **BREAK**

10:35 Seed Stock Supply
- Dr. Dave Scarratt

11:00 **Discussion**

11:10 Demonstration Salmon Farms
-Cage Culture
  - G. Henderson
-Landbased Culture
  - R. Biggs

11:50 **Discussion**

OYSTER CULTURE

Moderator: J. Campbell

09:30 Precis of Atlantic Oyster Industry
- J. Jenkins

09:50 Public Bed Enhancement Enhancement
- C. MacKenzie,Jr.

10:30 **Discussion**

10:45 **BREAK**
11:00 Private Lease Development
- E. Ferguson

11:45 **Discussion**

12:00 **LUNCHEON**
Dr. R.G. Thompson, Dean, AVC
"The Atlantic Veterinary College and Aquaculture"

TUESDAY, FEBRUARY 10, 1987 (AFTERNOON SESSION)

FISH HEALTH

Moderator: G.R. Johnson, D.V.M

13:30 Fish Health & Disease Control
- J. Cornick

13:50 **Discussion**

14:00 Water Quality
- E. Mason

14:20 **Discussion**

14:30 Nutrition
- Dr. C.Frantsi

14:50 **Discussion**

15:00 **BREAK**
15:15 Histology/Pathology
- Dr. B. Hicks

15:35 **Discussion**

15:45 Immunization
- Dr. W. Patterson

16:05 **Discussion**

16:15 Parasitology
- Dr. S. MacGladdery

16:35 **Discussion**

16:45 Rapportage

OYSTER CULTURE

Moderator: A. Morrison

13:30 Status of Belon Oyster Culture in Nova Scotia
- Dr. C. Enright

13:50 **Discussion**

14:00 Leasing Policy/River Designation System
- J. Jenkins

14:30 **Discussion**
14:45 **BREAK**

15:00 Marketing and Packaging
- Dr. C. Enright
- E. Ferguson
- J. Jenkins
- C. MacKenzie

15:45 Quahaug Culture
- R. Kraus

16:15 **Discussion**
16:30 Rapportage

19:00 **WORKSHOP BANQUET**
Peter Hjul, Editor, Fish Farming International
'International Aquaculture'

DAY 2

WEDNESDAY, FEBRUARY 11, 1987 (MORNING SESSION)

SALMONID CULTURE		MUSSEL CULTURE	
Moderator: L. Murphy		**Co-ordinator:** T. O'Rourke	
08:30		08:30	Mussel Culture Field Trip
09:00	Overwintering - L. Murphy		
09:20	Kelt Reconditioning - R. Grey		
09:40	Salmonid Biotechnology - Dr. B. Glebe		
10:00	Non-Salmonid Cultures - P. Hjul		
10:20	**Discussion**		
10:30	**BREAK**		
10:45	Marketing and Promotion - Panel - G.W. Wolfe - R. Robillard - W.L. Mockbee		
11:45	Rapportage	11:45	Return from Field Trip

12:00 **LUNCHEON**

WEDNESDAY, FEBRUARY 11, 1987 (AFTERNOON SESSION)

SALMONID CULTURE

Co-ordinator: L. Murphy

13:00 Salmonid Culture Field Trip

16:30 Return from Field Trip

MUSSEL CULTURE

Moderator: I. Judson

13:00 Opening Remarks
- B. Rowat

13:15 Precis of Mussel Culture
- I. Judson

13:30 Culture Biology of Mussels
- B. Myrand

14:00 **Discussion**

14:15 Leasing Policy/River Designation System
- J. Jenkins

14:45 **Discussion**

15:00 **BREAK**

15:15 Culture Techniques

- Spat Prediction
  - J. Campbell
- Site Selection
  - Dr. A. Maillet
- Intensive Culture & Productivity
  - W. Somers

16:00 **Discussion**

16:30 Rapportage
- M. Mallet

19:00 - 22:00 Informal Sessions with Resource Persons

DAY3

THURSDAY, FEBRUARY 12, 1987 (MORNING SESSION)

MUSSEL CULTURE

Moderator: R. Drinnan

09:00 Predation, Disease, Mortality
  - P. Darnell
  - Dr. A. Maillet
  - Dr. R.J. Thompson
  - G.R. Johnson, DVM

10:00 Panel Discussion

10:45 **BREAK**

11:00 Aquaculture: An Investor's Point of View
  - T. Hayes

11:20 **Discussion**

11:30 Cash Flow Management
  - D. Walsh

12:00 **Lunch**

THURSDAY, FEBRUARY 12, 1987 (AFTERNOON SESSION)

13:30 Mussel Processing for the Market
  - Dr. R. Ablett

13:50 **Discussion**

14:00 Air Transport of Live Shellfish
  - A. Rach

14:40 **Discussion**

15:00 **BREAK**

15:15 Marketing of Fresh Product - Panel
  - R. Dockendorff
  - I. Kerry
  - R. Robillard
  - P. Darnell
  - D. Walsh

16:00 Rapportage
  - M. Mallet

16:15 Closing Remarks
  - Y. Tournois

Appendix B

RESOURCE PERSONS

Dr. Richard Ablett
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Mr. Robert Brandano
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C0A 2B0

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Appendix D

NATIONAL POLICY GOALS FOR CANADIAN AQUACULTURE
(June 9, 1986)

To date, all the provinces and the territories, as well as the federal government, have had various measures to encourage commercial aquaculture development in Canada. Future development will be achieved through the combined efforts of industry and government working towards common goals. These goals embrace the following:

(i) TO ENCOURAGE THE DEVELOPMENT OF COMMERCIAL AQUACULTURE IN CANADA IN A MANNER THAT IS COMPLEMENTARY TO THE CONTINUING DEVELOPMENT OF THE WILD FISHERY;

(ii) TO INCREASE THE ECONOMIC RETURNS FROM INTENSIFIED PRODUCTION AND HARVEST OF HIGH VALUE, MARKETABLE SPECIES OF FIN FISH, SHELL FISH AND MARINE PLANTS IN THE REGIONS OF CANADA;

(iii) TO IMPROVE THE QUALITY AND EXPAND THE VARIETY OF CANADIAN FISH PRODUCTS;

(iv) TO IMPROVE THE RELIABILITY OF SUPPLY OF CANADIAN PRODUCTS TO BE MARKETED IN CANADA AND ABROAD;

(v) TO CREATE NEW EMPLOYMENT AND ENRICHED INCOME OPPORTUNITIES IN THE PRODUCTION OF FISH;

(vi) TO ENCOURAGE LONG-RANGE STABILITY IN THE COUNTRY'S FISH PRODUCTION SECTOR THROUGH DIVERSITY AND CONTINUITY OF SUPPLY; AND

(vii) TO PROMOTE THE DEVELOPMENT AND APPLICATION OF THE MOST ADVANCED TECHNOLOGIES FOR INTENSIVE PRODUCTION AND MARKETING OF FIN FISH, SHELL FISH AND MARINE PLANTS ACROSS CANADA.

In pursuit of these goals, the following **basic principles** have been adopted:

(i) THE PRIVATE SECTOR SHOULD BE RELIED UPON TO ESTABLISH AQUACULTURE VENTURES AND TO MARKET THE RESULTING PRODUCTS TAKING ADVANTAGE OF EXISTING STRUCTURES WHERE APPLICABLE;

(ii) THE FEDERAL GOVERNMENT AND THE PROVINCES/TERRITORIES SHOULD CO-ORDINATE THEIR EFFORTS TO ENSURE THE ORDERLY DEVELOPMENT OF COMMERCIAL AQUACULTURE IN CANADA;

(iii) MEMORANDA OF UNDERSTANDING TO PROMOTE COMMERCIAL DEVELOPMENT SHOULD BE ENTERED INTO A BILATERAL BASIS SO AS TO RECOGNIZE REGIONAL DIFFERENCES;

(iv) THE REGULATORY FRAMEWORKS OF GOVERNMENTS SHOULD BE CLARIFIED FOR COMMERCIAL AQUACULTURE DEVELOPMENT;

(v) GOVERNMENT PROGRAMS SHOULD PROVIDE SUPPORT TO THE AQUACULTURE INDUSTRY IN SOME KEY STAGES OF DEVELOPMENT;

(vi) THE FEDERAL GOVERNMENT SHOULD CONTINUE TO MAINTAIN A RESPONSIBILITY FOR FISH HEALTH IN GENERAL, INCLUDING ALL CULTURED SPECIES;

(vii) CONTINUING DIALOGUE BETWEEN THE AQUACULTURE INDUSTRY AND GOVERNMENTS SHOULD BE ENCOURAGED; AND

(viii) IN ORDER TO IMPROVE THE TECHNOLOGICAL BASIS FOR COMMERCIAL AQUACULTURE, GOVERNMENTS SHOULD WORK CO-OPERATIVELY WITH INDUSTRY IN PROMOTING AND CONDUCTING R & D AND TRANSFERRING THE RESULTING BENEFITS.

The complete text of Dr. Chris Frantsi's presentation was not available on the date of publication. An abstract has, therefore, been prepared for presentation here.

PRECIS
NUTRITION
FISH FEEDS - STATUS AND NEEDS

by
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In this presentation, the Connors Bros. Ltd. (New Brunswick) operation is cited as an example of an integrated aquaculture/fish feed manufactory. The operation produces and uses a moist feed (moisture level, 30-40 per cent), but formula preparations vary throughout the year, due to the nature and sources of components. There is a need for strict quality control and proper cooling and holding facilities. Future formulations will attempt to combine the softness and palatability of moist feeds with the keeping quality and pellet integrity of dry feeds. There must be better definition of fish nutritional requirements and genetic stocks must be improved. Concern is expressed about the proliferation of regulatory involvement by agencies outside of the aquaculture industry.