Salmon Aquaculture in the Bay of Fundy
An Unsustainable Industry

Janice Harvey and *Inka Milewski*

Conservation Council *of* New Brunswick
Conseil de conservation *du* Nouveau-Brunswick

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Janice Harvey and Inka Milewski

Conservation Council of New Brunswick Inc.

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This publication is part of the Conservation Council's effort to promote the sustainability of marine-based economic activities through its Fundy Baykeeper Program.

The Conservation Council's mission is to create awareness of environmental problems and advocates solutions through education, public engagement, networking and interventions. In addition to responding to public issues as they emerge, CCNB also acts on its mandate through four major program areas: Marine Conservation / Fundy Baykeeper, Acadian Forest Conservation, Environmental Justice and Climate Change.

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As the principal writer of this report, I have depended heavily on the work and insights of others to inform my thinking and provide the scientific and technical substance for it. I especially wish to acknowledge the Conservation Council's science advisor Inka Milewski for her contribution. Inka is continually immersed in the scientific literature in this field. She is not only abreast of the latest developments but is often ahead of them. She asks the hard questions and pushes for answers from those agencies responsible for regulating the aquaculture industry. Where answers are not forthcoming, she goes looking for them herself, setting up her own experiments, raising the money to support them, and hitting the water.

Inka's persistent pushing of the government science agenda on both finfish and shellfish aquaculture has dramatically influenced the way both industries are regulated in this region. All this work goes unnoticed by the public because it is done out of the public eye and does not make for riveting news. However, we all owe her a great debt of gratitude for her personal integrity and professional pursuit of making science work to protect the public trust inherent in our marine and coastal environment.

The Conservation Council also wishes to acknowledge the important contribution of Dr. Barry Hargrave and Dr. Peter Strain to our understanding of the ecological impacts of finfish aquaculture. While several scientists have carried out important research in this area, Hargrave (now retired) and Strain (now working for DFO in British Columbia) stand out not only as senior researchers but also as advocates for a regulatory system that will better protect the marine environment from the impacts of finfish aquaculture. As leader of DFO's Environmental Studies for Sustainable Aquaculture (ESSA) program, Dr. Hargrave invited the Conservation Council to participate in the review of their research and was readily accessible to explain, consult and elaborate as we integrated ESSA research into our own work.

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Finally, the financial means for the Conservation Council of New Brunswick to pursue this work comes from independent sources that are prepared to invest in a distinctly low-profile area of the country and in a national sense, a low-profile issue. There is nothing splashy about this work, but our funders understand that our work here contributes to the profound change that needs to be made in the way society views and exploits our oceans, which are in such serious trouble.

The J. M. Kaplan Fund and the T. R. Meighen Family Foundation has stepped up to help advance our collective understanding of what constitutes sustainability – and what does not – in the aquaculture field. The EJLB Foundation supported the Crow Harbour monitoring program and our related work on nutrient pollution in New Brunswick's estuaries and bays. More generally, the T. R. Meighen Family Foundation, the W. Garfield Weston Foundation and the McCain Foundation all support the Fundy Baykeeper Program under which umbrella this and other aquaculture related issues are addressed including the widespread problem of aquaculture debris despoiling beaches and shoreline, marine hazards relating to abandoned equipment, the illegal use of beaches for building and tending fish farms, expansion of the industry into undeveloped areas, and pollution from the farms. In addition, many of the individuals who support the Conservation Council of New Brunswick through donations and memberships, especially Friends of the Fundy Baykeeper, do so because of our attention to the impacts of aquaculture on the Bay of Fundy.

CCNB thanks all these individuals and organizations for their contributions to our work. That said, this report reflects the expressed views of the Conservation Council. Responsibility for any errors rests solely with the author.

Janice Harvey
Director, Fundy Baykeeper Program

Preface

The Conservation Council of New Brunswick's first report on salmon aquaculture in the Bay of Fundy was published in November 1997. *After the Gold Rush: the Status and Future of Salmon Aquaculture* in New Brunswick has stood the test of time as a definitive critique of the development of the industry in New Brunswick and the failure of governments, federal and provincial, to properly regulate and control its expansion

Not by design on our part, *After the Gold Rush* went to press at the height of industry upheaval and uncertainty. In the preface to that report, we wrote:

By the time you read this report, there will be new developments in many of the issues we have covered in it. Such is the dynamic nature of the salmon aquaculture enterprise in New Brunswick today. Although it was difficult to do, after a year of working on this project, we had to put down our pens and take it to print. This despite the fact that major decisions on critical problems are imminent:

- *what should be done about polluted Lime Kiln Bay and Bliss Harbour;*
- *is Infectious Salmon Anaemia (ISA) the disease decimating one quarter of the New Brunswick salmon farms;*
- *should a slaughter order be given for ISA-infected farms;*
- *if infected farms are ordered to slaughter their fish, should taxpayers provide the companies with compensation;*
- *should ISA-affected companies be given new sites in clean areas so they can get their 1998 smolts in the water?*

In the midst of crisis, the New Brunswick Minister of Fisheries and Aquaculture announced a review of the policy governing the development of the salmon aquaculture industry. This is underway now and is expected to produce a new policy document sometime in 1998.

Much water has flowed past the salmon cages in the ensuing years. Ten years later, the industry is much larger than it was in 1997 although consolidated into a near monopoly by one company; profit margins have shrunk considerably; policy and regulatory regimes changed and are changing again; research is finally shedding some light on some longstanding questions about the environmental impacts of intensive finfish net pen culture; diseases are being "managed" rather than eradicated; space conflicts in the crowded coastal zone have heated up dramatically; and the confidentiality of industry information has been cracked at least to some degree. Two auditors-general reports have criticized federal and provincial regulation of the industry and similar criticism has come from committees of both the House of Commons and the Senate.

Yet the environmental issues we profiled in 1997 remain. Indeed, the evolution of the industry and information about it has deepened our understanding of the intractability of problems generated by industrial-scale, open net pen aquaculture, the business model and technology used in salmon farming. By definition, growing fish in this manner inevitably results in direct discharges of various pollutants to the marine environment, negative interactions with wild species and conflicts with traditional fisheries and other coastal uses. In short, it is unsustainable.

We have produced this second report to elaborate on such issues. In particular, this report comprises an important baseline of information for new work by the Conservation Council to consider what constitutes "sustainable" aquaculture in the Bay of Fundy and Gulf of Maine. Today, all government and industry literature and public statements refer to the existing industry as "sustainable." This report suggests this label is not justified and points to changes that have to be made to make it so.

As always, we are careful in this report to cite reliable sources of information while we provide our own perspective as a citizen's environmental watchdog group. We trust it will inform the ongoing public debate on what is going on in our coastal zone and how those activities should be managed to protect the Bay of Fundy, a public trust resource.

Conservation Council of New Brunswick

1. The Test of Sustainability

The litmus test for economic development in the 21st century will be whether or not it is sustainable. Popularized in 1987 by the World Commission on Environment and Development (the Brundtland Commission) convened by the United Nations, the concept of sustainable development was expressed as development that meets the needs of this generation while not diminishing the ability of future generations to meet their own needs.[1] While much lip service has been offered up in the name of sustainability since then, the climate and biodiversity crises now upon us have sharpened public and political consciousness of the need to transform our economy to meet the challenge of staying within the ecological limits imposed by Planet Earth.

As a major economic player in the Bay of Fundy – Gulf of Maine, the salmon aquaculture industry requires a serious analysis of its sustainability quotient, primarily because this industry takes place in public waters and on public shorelines and impacts public resources. While both industry and government invoke the language of sustainability to describe salmon aquaculture as it is practised here, the on-the-water reality is quite different. By definition, the concept of sustainability is interdisciplinary (ecological, social, cultural and economic) and covers a time scale which outlives short-term political decision-making and economic planning. While there are more detailed definitions of sustainable aquaculture, a general framework could be as follows:[2]

- It does not degrade the ecosystem on which it is dependent.
- It is in harmony with other economic, social and cultural activities that use the same natural resources.
- It invests in local communities and decision-making is local.
- It produces a reasonable and relatively stable net income or benefit to both producers and society by using natural resources on a long-term, renewable basis.
- It does not diminish the ability of future generations to use the same natural resources.

Costa-Pierce breaks down the first element much more finely to include preservation of the form and function of natural ecosystems; trophic level efficiency (no net loss of protein); and avoidance of nutrient, chemical and biological pollution.[3]

In the past 25 years, generous government support, scientific curiosity and the outer Bay of Fundy's physical features have given rise to the largest aquaculture industry on the Atlantic coast. Introduced in 1978, Atlantic salmon farming in New Brunswick is concentrated in Charlotte County, although the most recent fish farm site approvals have crossed the boundary line into Saint John County. In May 2006, the 99th salmon site was approved in Haley's Cove, just east of Chance Harbour.[4] The largest concentration of salmon farms in Maine is in Cobscook Bay, also part of the Fundy ecosystem.

Since its beginnings in New Brunswick, salmon aquaculture has been considered by all levels of government as an economic miracle to a region beset by seasonal employment fluctuations and declines in traditional fisheries. This has made governments reluctant to objectively evaluate the real costs of the industry – economic, social and ecological – and to establish a regulatory and policy framework that would meet even minimal sustainability criteria for this industry.

It was only when the wheels started to fall off the bus (e.g. sea lice and disease epidemics, low prices, opposition to new sites) that governments began to admit to the problems and attempt to establish itself as a credible regulator. Since 1997 when CCNB published its first report on salmon aquaculture, several policy and regulatory reviews have taken place provincially and federally and changes came into effect in 2000-2001. Ten years later, these changes have failed to solve the problems and further changes were made in 2007.

Perhaps not surprisingly, the salmon aquaculture industry has followed the same development model as industrial livestock production. Production of farm-raised fish looks remarkably similar to production of cattle, hogs or chickens in confined animal feed operations (CAFOs) or industrial livestock operations (ILOs). Such animal operations rely on manufactured feed, medications to prevent or treat diseases and parasites which are an unavoidable result of stressed animals kept in unnatural conditions, and produce concentrated volumes of polluting waste products which become serious environmental and health problems.

Three dimensions of salmon aquaculture work synergistically to create unsustainable conditions within the salmon growing areas. These are technology, scale and physical space needed for fish farms. The technology typically employed by salmon farmers is called open net-pen aquaculture. These are large nets hung from floating frames or collars and anchored in place in coastal waters, most no further from shore than a few hundred meters. All wastes generated on the site move through the nets into

the water column and are dissolved or fall onto the seafloor.

With this type of technology, only a small scale aquaculture industry could locate in inshore waters without posing a pollution problem and impacting inshore fish habitat. At the industrial scale now practised, serious ecosystem impacts have been demonstrated in some areas. Yet there is still a dearth of scientific understanding of the impacts of chemicals and other pollutants from aquaculture sites on sea creatures. The precautionary principle, an integral component of sustainability, suggests that rather than assume no effects, we should proceed with great caution until and unless we know that no harm will result from our activities. Instead, as salmon aquaculture has developed, environmental protection and research into ecosystem effects have been afterthoughts, like closing the barn door after the horse is long gone.

Further, fish farming is taking place on the very fishing grounds that have supported the commercial wild fishery for centuries. The displacement of traditional fishing activity to make room for an expanding salmon farming industry creates community conflict and imposes costs on sectors that do not benefit from fish farming activity. Other community conflicts have arisen around the use of public beaches as staging areas for aquaculture operations, widespread despoiling of shorelines by abandoned aquaculture equipment and debris, and noise from cage sites disturbing coastal landowners.

These factors lead us to conclude that the salmon aquaculture industry fails the test of sustainability. Its establishment and survival have depended heavily on significant public concessions. These concessions are financial, but they are more than that. They are also in the form of ceding even more of the coastal zone and public trust resources – fishing grounds, fish habitat, water quality and biodiversity, and shoreline integrity – to the aquaculture industry's use. They also relate to the appropriation of ecosystem resources required for maintaining marine food webs and for providing high protein, low cost fish for food fisheries.

This report explains each of these factors by outlining the story of salmon aquaculture development in the Bay of Fundy – Gulf of Maine. By looking at the evolution of the industry from its inception, how it has been subsidized and regulated, and the research into its impacts, we will demonstrate that there have been significant social, economic and ecological costs imposed by the industry that have not been weighed against the jobs and other economic activity it has generated.

2. The Salmon Aquaculture Industry

New Brunswick Industry Profile

Prized by commercial and recreational fishers alike, Atlantic salmon has been the subject of extensive scientific research and management activities in Canada for at least a century. Today's commercial aquaculture industry in the Gulf of Maine was spawned by the 1976 visit of Dr. Arnold Sutterlin, a scientist at the federal Department of Fisheries and Oceans Biological Station in St. Andrews, New Brunswick, to Norway for a sabbatical year. In the early 1970's Norwegians had made some major breakthroughs in raising Atlantic salmon in marine enclosures. Dr. Sutterlin's considerable knowledge of salmon physiology, particularly the process of smoltification - the physiological and behavioural changes young salmon undergo in order to make the transition from fresh to sea water - was of special interest to them.

When Dr. Sutterlin arrived in Norway, annual production of farm-reared salmon in that country hovered around 2,000 tonnes. He became convinced of the feasibility of a similar industry in Atlantic Canada, envisioning that salmon aquaculture could provide a secure community-based industry to buffer the troughs of the inshore herring weir fishery which dominated the fishing economy at the time.[5]

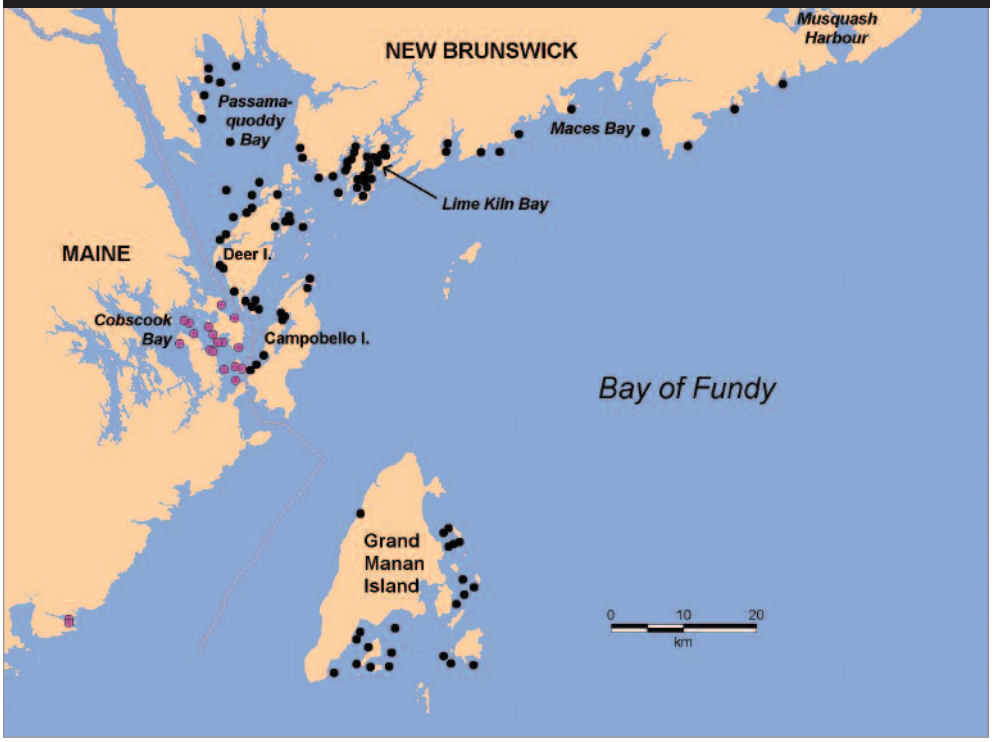
On Dr. Sutterlin's return to Canada, he and other federal government scientists assisted the New Brunswick government, a private company, Marine Research Associates, and some herring weir fishermen to establish an experimental salmon farm in Lord's Cove, Deer Island. In 1978, 3,500 salmon smolts were placed in sea cages and in 18 months six tonnes of salmon at 3.3 kilograms average weight were ready for market, demonstrating that salmon farming was possible in this region. The fish sold at $7.70/kg (dressed), for a total value of over $46,000.

Nonetheless, the industry got a slow start. By 1984 only five salmon farms were operating, producing 255 MT. A major constraint on its development was the availability of smolts for commercial operations. Smolts are young salmonids that are ready to make the transition from freshwater to marine habitat.[6] Until 1979, there had been no market demand for smolts and therefore no private sector production. Thus early fish farmers were limited to the smolts left over from river stocking programs supplied by government-run hatcheries.

Then in 1985, Sea Farm Canada (later Stolt Sea Farm), a large Norwegian company in partnership with the equally large Canadian company Maple Leaf Mills, built a commercial smolt production facility at Digdeguash Lake, just inland from the coastal salmon sites. A year later the new hatchery put one million smolts on the market. The same year, Connors Brothers Ltd., the largest sardine producer in Canada and then a subsidiary of George Weston Limited, Canada's largest food conglomerate, began a commercial smolt production operation. Connors Bros. also began a fish farming company called Heritage Salmon. After a major buy-out in Maine, Heritage Salmon became the single largest producer of farmed salmon on the east coast of North America. George Weston Ltd. later divested itself first of Connors Bros., and then in 2005 of Heritage Salmon.

With a key constraint to production overcome, the number of salmon farms in southwestern New Brunswick skyrocketed from five in 1984 to 28 in 1986, all within a small area at the

Figure 1. Salmon Aquaculture Leases in New Brunswick and Maine 2006



Salmon aquaculture leases approved in New Brunswick (black) and Maine (pink) in 2006. Although 99 leases have been approved in New Brunswick, bankruptcies and closures of some sites resulted in fewer than 80 submitting environmental monitoring reports in 2005. Source: St. Andrews Biological Station, DFO.

mouth of the Bay of Fundy. The average per site production of salmon was 25 tonnes (over 7,000 fish) raised in eight to 10 sea cages, almost triple the production of the first farm. These farms required a market price of $7.80/kilogram ($3.55/lb) to turn a profit. In 1986, the price for farmed salmon on the US market where they were mostly sold was $12.69/kilogram. This high price drove an ever-increasing demand for farm site leases by new entrants into the industry.

That year, a moratorium of sorts was imposed on new site applications to allow the government to catch up on the backlog of approvals, draft some badly needed legislation to govern the industry, and take a first look at emerging environmental and fisheries issues.[7] Even so, new sites continued to be announced as the provincial Department of Fisheries (later Fisheries and Aquaculture - DFA, and then Agriculture, Fisheries and Aquaculture – DAFA), worked through the backlog of applications. The nominal moratorium was lifted in 1988.

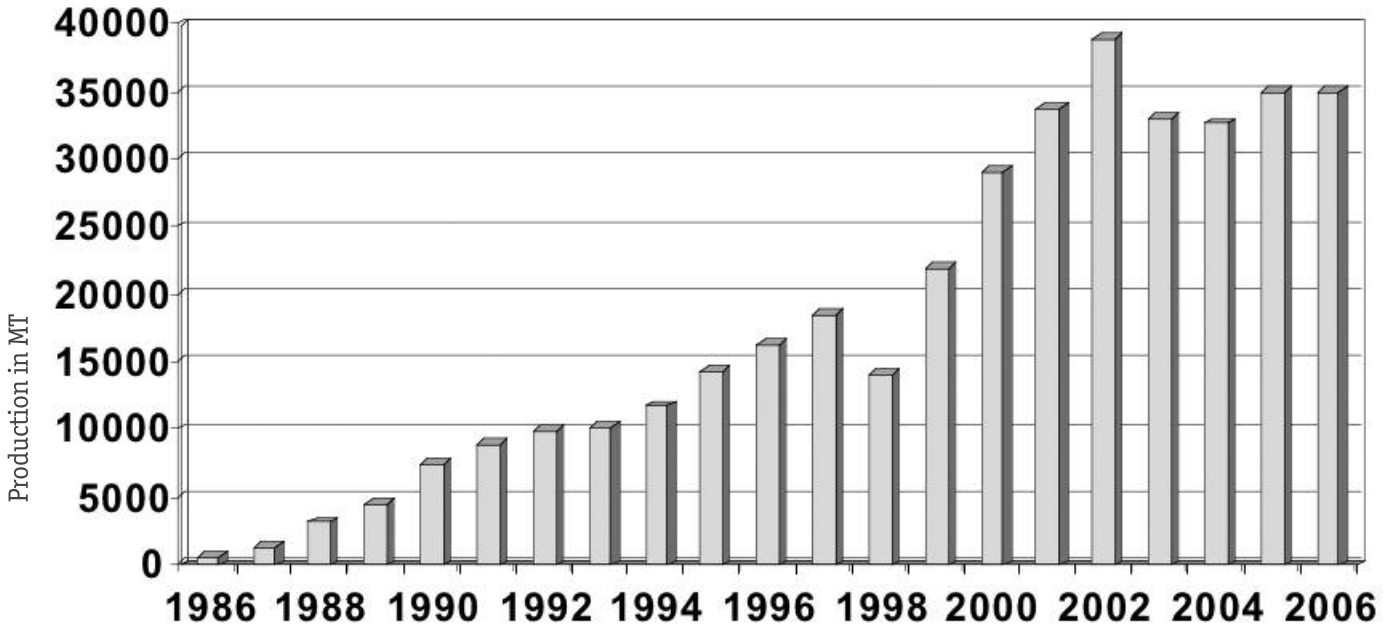
By the late 1980's, the Charlotte County coast had the look and feel of a gold rush. But instead of sluice boxes on river banks, sea cages of all shapes and sizes dotted the shoreline. There were 52 farms in operation at the end of the first decade, a ten-fold increase in six years. Total production value had reached $71.9 million and service industries needed to support the salmon rush such as net and feed manufacturers had been established. Hatcheries were producing 2.5 million smolts each year for commercial production.[8] What were locally referred to as "salmon mansions" sprang up along the winding roads to the coast, the most obvious evidence that salmon farming was paying off for those early farmers.

The rapid growth of the industry led some salmon farmers to realize they needed a coordinated voice to represent their interests. In 1987, they banded together to form the New Brunswick Salmon Growers Association (NBSGA). This organization's mandate was to handle government and community relations; coordinate research and development into technical aspects of salmon; and promote New Brunswick salmon to major markets such as New York and New England (75 to 80 percent of Charlotte County salmon goes to the US market[9]). Over the next decade, the association would receive over $4.3 million in government contributions for its work.

By the early 1990's, the number of new farms coming into production and the volume of salmon being produced began to slow down. In 1992, there were 56 licensed farms. Between 1992 and 1996, a total of 21 sites were licensed, bringing the total to 77. Several more sites were approved in 1997, with another 50 applications in government files waiting to be processed.

Over the same period, the price paid to the farmer was dropping. A dramatic price slump in 1989 imposed some

Figure 2. Salmon Aquaculture Production in New Brunswick in Metric Tonnes – 1986 - 2006



Data from DFO Statistical Services/Statistics Canada and the Province of New Brunswick (departments of fisheries and aquaculture).

realism on the industry. From a high of $6.35/lb in 1987, the price dropped to $4.25. It crept up slightly over the next two years, but then it began a persistent downward trend, bottoming out in 1996 at $2.00/lb before edging up only slightly.[10]

This was the beginning of a painful industry restructuring in New Brunswick and Maine. The North American industry, including multinationals, had been increasingly squeezed by a chronically depressed market price resulting from a flood of Chilean-produced salmon. By 2003 Chile had surpassed Norway as the largest supplier of farmed salmon to the world market with no end of expansion in sight. From January to September 2003, at an average price of US$3.22/lb, Canadian exports to the US decreased by 20 percent, while Chile, at an average price of US$2.14/lb, provided fully 83 percent of US farmed fillet consumption.[11]

Over the period from the mid-1990s to 2005, efforts to reduce costs through economies of scale forced 10 to15-fold increases in the number of fish per site, with some sites holding a million or more fish. With this growth came disease and parasite epidemics, the combination of which forced many independent farmers out of business, selling their operations to larger companies. The number of companies operating in the outer Bay of Fundy dropped from approximately 45 in 1995 to eight in 2007, while the number of farm sites increased from 71 to 99, and production grew from approximately 15,000 MT to a high of nearly 39,000 MT in 2002. Production in 2003 dropped to 33,000MT and again in 2004 to 32,700MT. It climbed slightly to 35,000 MT in 2005.[12]

By 2004, the salmon aquaculture industry in New Brunswick was dominated by three corporations: Heritage Salmon, Stolt Sea Farm and Cooke Aquaculture. Together they owned or had a direct stake in about 53 of the 97 fish farms.

Despite all the bankruptcies and consolidation throughout the 1990s and early 2000s, for at least two large corporations, Heritage Salmon and Stolt Sea Farm, their vertical integration and economies of scale did not deliver profits. The George Weston annual report indicated that Heritage Salmon lost $26 million in 2002 and $20 million in 2003. In 2004, losses were much greater. After posting early losses, in the fourth quarter of 2004 Heritage sold its Chilean operations to a Chilean company for $20-million, amounting to a pre-tax loss of $9-million. Weston then wrote down the value of Heritage Salmon by $147-million, declaring it a "discontinued operation."[13] The result was a year-end loss of $178-million (including the write-down).[14] A company spokesman characterized the company's troubles that have been "mounting for years" as "an oversupply of stock as more companies entered the aquaculture business in recent years; the rise of the Canadian dollar against its US counterpart; the outbreak of disease that affected fish stocks and reports that farm-raised salmon contains toxins that can cause cancer."[15]

While earlier news that Heritage Salmon's Chilean operations were for sale should have been a tip-off, the company's 569 workers in Charlotte County, industry watchers and coastal communities were surprised and troubled to learn on February 15, 2005 that George Weston Ltd. had hung the "For Sale" sign once again on Heritage Salmon (Weston had it on the market a few years earlier but took it off when no suitable offers came in). After sustaining several years of aquaculture losses, the company decided to shed itself of the non-core fish business to focus on bakery and retail. A stock analyst commented on the news, "They thought they'd tough it out until the industry turned, and I guess they're coming to the conclusion it won't for a long time." [16]

The second largest player on the east coast was also in difficulty. Norwegian-based Stolt Sea Farm, lost US $20-million in 2002. In 2003, losses totaled US$63-million. While things turned around somewhat in the first half of 2004, they posted a loss of US$11.6-million in the third quarter and estimated losses of between US$1-million and US$4-million in the fourth. The company cited low global salmon prices due to overproduction, hatchery closure and "reorganization provisions" and disease problems in Canada and Norway, and improved prices in the fourth quarter for the reduction in losses.[17] [18]

These companies had operations on both coasts of Canada so their losses were across all their operations. Other big corporate players in Canadian salmon aquaculture - Nutreco (Netherlands), Pan Fish (Norway) and Cermaq (Norway) – have also experienced losses.[19] These companies operate in British Columbia, and many other countries.

As Weston was liquidating its Chilean operations and preparing to announce that Heritage Salmon is for sale, the two European aquaculture giants were also taking steps to address their losses. In September 2004, Stolt-Nielson S. A. and Nutreco Holding N. V., which owns the world's largest aquaculture company Nutreco Aquaculture and its fish farming arm Marine Harvest, announced the merger of their respective aquaculture operations. (While Nutreco does not operate fish farms in New Brunswick, the corporation's animal feed company Skretting owns the former Moore-Clark fish feed manufacturing operation at the Bayside Industrial Park near St. Andrews).

According to a news release, the two companies signed a "Memorandum of Understanding to merge their world-wide fish farming, processing and marketing-sales operations into a stand-alone, independently financed new business entity." Nutreco would hold a 75 percent stake and Stolt - Nielson a 25 percent stake in the new company, Marine Harvest. The new company "will incorporate annual sales of approximately EUR 1 billion in salmon, salmon trout and other farmed fish". Based in the Netherlands, Marine Harvest would be "headed by Mr. Hans den Bieman, currently chief operating officer of Nutreco Aquaculture."[20]

What was called a merger looked more like a bail-out of Stolt Sea Farm. There can be no question that the deal was a response to the failing salmon business. Mr. Wout Dekker, Nutreco's chief executive officer, commented, "Nutreco and Stolt have long recognized the need for further consolidation in the industry. We expect the merger to act as a catalyst for the awaited restructuring of the international salmon industry."[21] Another Nutreco spokesman was quoted as saying the company would be better off concentrating its operations in Chile and the west coast of North America, rather than the east coast and Scotland.[22] The implication was that problems plaguing the North Atlantic industry – disease, sea lice and limited space – made salmon farming here unprofitable, compared to other regions.

This paved the way for an announcement in April 2005 by Cooke Aquaculture, a privately-owned New Brunswick company, that it would purchase the east coast holdings of Stolt Sea Farm. While descriptions of the assets to be acquired varied, one account described them as 20 salmon sites in both New Brunswick (14) and Maine (6), one cod site, two hatcheries, a processing plant in St. George, a marketing and sales division, and a value-added plant in Connecticut. These operations employed 300 people.[23]

Before this deal was finalized, however, another announcement from Cooke Aquaculture threw local communities into a tailspin. That company would also buy Heritage Salmon, consolidating nearly total control of the east coast industry including New Brunswick, Maine and Nova Scotia, in the hands of one private company. While Cooke Aquaculture has reportedly managed to be profitable and attract significant venture capital to support its buy-outs and expansions,[24] larger corporations operating on several national or regional fronts had been losing money and independent growers driven into bankruptcy or vassalage to corporate operations.

Ironically, while the vertically integrated industrial food production model has been touted as the only financially viable corporate structure for salmon aquaculture, this

Company Profile: Cooke Aquaculture

Begun in 1985 with one salmon farm, Cooke Aquaculture is a private family-owned company that has grown to corporate status with its 2004 take-over of Atlantic Salmon of Maine, and in 2005 of the east coast operations of both Heritage Salmon and Stolt Sea Farm. Their products are marketed under the True North Salmon and Atlantic Fish Specialties labels, as well as former Heritage Salmon and Stolt Sea Farm labels.

According to the company,[26] Cooke Aquaculture is now "the largest fully integrated, independent aquaculture company in North America as well as one of the top 10 salmon companies in the world. Their holdings include 11 certified hatcheries, 110 fish farms, processing and sales, services, equipment manufacturing, transportation, and by 2008, a dry feed plant. They have operations in all four Atlantic Provinces, and Maine, with 25 million fish in the water and three million in their hatcheries. In 2007, they expect to produce a total of 45,000 MT, growing to 75,000 in five years. This includes plans for nine new sites in Fortune Bay, Newfoundland, part of a $155 million investment, including $20 million from federal and provincial coffers.[27] In July 2007, Cooke purchased a Shur-Gain dry feed plant in Truro, Nova Scotia, completing its corporate strategy of vertical integration of all aspects of the industry, from hatchery to processing and marketing.[28] Company sales in 2006 totaled $205 million and are projected to be $270 million in 2007.

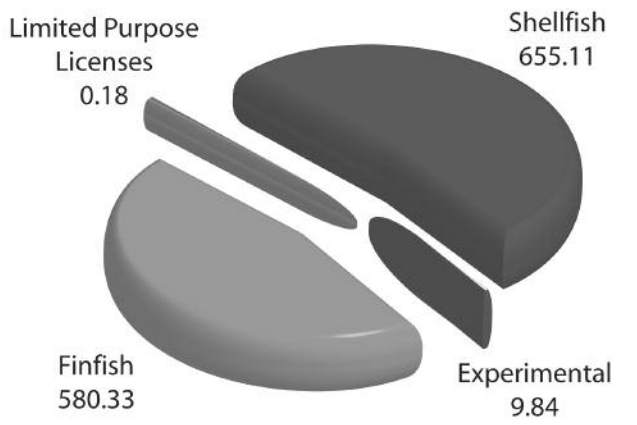
In addition to salmon, Cooke Aquaculture has three cod sites in New Brunswick (first harvest was in 2006) and has invested $18 million in a cod broodstock program. They are also moving into mussel and sea plant production associated with several salmon farms, called multi-trophic production. They have consolidated seven processing facilities into two, a whole fish plant in Black's Harbour, New Brunswick and a value-added plant in St. George. Marketing and sales are headquartered in Black's Harbour, with satellite offices in Boston, New York, Chicago, New Jersey, Quebec and Toronto. Half their product is sold in Canada and the other half in the US.

same model has produced the glut of farmed salmon on the global market which results in chronically depressed prices in the lucrative North American market. The only way to get the price up is to cut global production or consolidate the industry to the point where a few companies can control and manipulate the market.

To this end, the international consolidation process has continued. Only one year after the creation of Marine Harvest by Nutreco and Stolt Neilson, another Norwegian giant, Pan Fish, which has operations in British Columbia but not the east coast, swallowed Marine Harvest. This resulted in a near complete rationalization of the global salmon aquaculture industry, with one Norwegian company cornering nearly two-thirds of the global market. Besides more market power in fewer hands, job loss in coastal communities is the inevitable result. In Scotland, an estimated 2,000 jobs have been lost since 2002 because of business failures and amalgamations in the salmon aquaculture industry. Another 500 jobs were expected to disappear as the result of the Pan Fish takeover of Marine Harvest.[25]

An estimated 500 people lost their jobs in Charlotte County, New Brunswick as a result of consolidation and business failures, although some job recovery may have occurred. These losses were on fish farms, in processing plants, and in related support industries. Maine has also lost many aquaculture jobs, some as Cooke Aquaculture bought Maine operations and centralized processing in New Brunswick plants, and others as the industry there shrank due to disease problems.

Figure 3. Acreage of Maine Waters Leased for Aquaculture Categorized by Lease Type



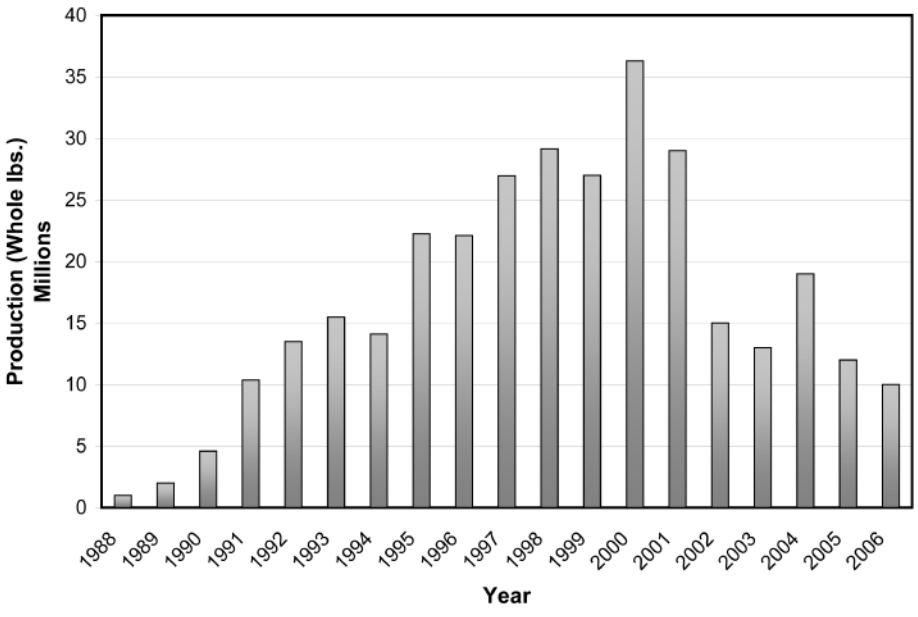
Source: Maine Dept. of Marine Resources website

The greatest concentration of salmon leases is in Cobscook Bay, immediately adjacent to Canadian salmon aquaculture operations. Several other sites are scattered down the coast of Maine towards Blue Hill Bay, but vociferous public and fishermen opposition to new sites has effectively frozen the expansion of finfish operations. As a result, shellfish aquaculture, which is perceived to have less of an ecological impact and be less of an imposition in coastal waters is growing in popularity. In 2004, finfish leases occupied 708 acres while shellfish leases occupied nearly 567 acres. The next year, shellfish leases at 655.11 acres surpassed finfish which shrank to 580.33 acres.[29]

Maine Industry Profile

The salmon aquaculture industry in Maine, although located within a stone's throw of its Canadian counterpart, has developed much more slowly and modestly. Drawing on the experiments in the early 1980s in New Brunswick, salmon aquaculture became established in Maine's Cobscook Bay in 1982 with the start up of Eastport-based Ocean Products Inc. In two years, the company was growing 63,000 fish in 12 pens. The next wave of fish farms came in 1986-87, set up by former Ocean Products employees, local fishing families and graduates of an aquaculture training course at the regional vocational school. Following these original entrants were subsidiaries of large companies.

Figure 4. Maine Finfish Aquaculture Harvest



By 1997, the transformation of the Maine salmon industry from family farms to a few vertically integrated companies had taken place.[30] This concentration would only intensify over the next several years. Total production levels in Maine reflect the same trends as in New Brunswick. After a period of intense expansion to try to overcome low prices, production declined dramatically as fish farms were hit by infectious salmon anemia, bankruptcies and a court ruling which ordered two companies to shut down farms for a period of time. The one factor Maine farms have not had to deal with is the rising Canadian dollar, which has squeezed Canadian companies hard since 2003-04.

As in Canada, the combination of low salmon prices and disease problems pushed many operations to the edge, leaving them ripe for buy-outs by larger companies. Cooke Aquaculture took over Atlantic Salmon of Maine in 2004. There was quite a stir when Cooke proceeded to close the salmon processing plant it acquired in Machiasport as part of that take-over. A Cooke spokesman explained that because of disease problems, production on the acquired fish farms was not sufficient to support a separate processing facility. Those salmon would instead be transported to a Cooke processing plant in New Brunswick, resulting in the loss of many jobs in the small Maine town.

According to the 2004 Maine Aquaculture Lease Inventory, there were 42 finfish aquaculture leases current in that year, only 23 of which were active. Eleven were held by Heritage Salmon (including leases under the name of Maine Coast Nordic), seven were held by Cooke Aquaculture (under the name of Atlantic Salmon of Maine LLC), and seven were held by Stolt Sea Farm. The remaining 15 were held by seven companies not obviously affiliated with the "big three" but those associations could exist. By 2006, Cooke Aquaculture held 25 out of 42 leases. Two finfish lease applications submitted in 2004 by Heritage Salmon would also go Cooke Aquaculture with their buy-out of Heritage assets. Today, the Maine finfish aquaculture industry looks more like a grow-out region for Cooke Aquaculture than a fully integrated independent industry.

Over the years, salmon aquaculture became a significant economic player in downeast Maine. In 2000, when salmon production reached an all-time high of 36.3 million lbs (16,500 MT) from 28 farms, it accounted for more than $100 million in sales and 1,200 jobs in the area. However, today many fewer people are employed and production is less than a third of what it was in 2000.

From this high, 2003 production of 13.2 million lbs (6,000 MT) from 14 farms was less than 1992 production of 13.5 million lbs (6,119 MT). The biggest factor in this decline was the outbreak of the infectious salmon anemia virus in February 2001, resulting in the cull of over two million salmon. The bay, where 26 of Maine's 42 salmon aquaculture leases are located, was completely emptied of fish farms by February 2002, the first time in 20 years. Nonetheless, this drastic measure did not halt the disease. The next year no cases of ISA were found, but two sites were infected in 2003, and five in 2004. In January 2004, 43,000 fish were culled from two sites owned by Stolt Sea Farm. Other infected sites were harvested and the fish marketed.[33] Salmon production never recovered. After an increase in 2004 (18.8 million lbs – 8,500 MT from 15 farms, 2005 production fell to 11,600 million lbs (5,263 MT) from just 8 salmon farms.

Several legal actions have contributed to the industry's troubles in Maine, something the New Brunswick farmers have largely avoided. A case filed in 2000 by two environmental groups and several private citizens alleged the companies were violating the *Clean Water Act* by not having been issued a *Clean Water Act* pollutant discharge permit. In February 2002, the magistrate found in their favour, judging non-native fish (escaped farmed salmon), fish food and chemicals released from the farms to be pollutants. This ruling led to two of the three companies operating under a consent decree, the conditions of which were more stringent than the water quality permit which was eventually adopted. The companies' subsequent attempt to have the consent decree conditions lifted once the permit was in place was turned down by the court. The court did rule that those conditions might be lifted once the companies demonstrated that previous harms had been remedied.

In January 2002, several criminal charges were laid against Heritage Salmon for failing to comply with the state's requirement for reporting their fish health surveillance results within a certain time frame. That same month, the citizens' group Friends of Blue Hill Bay filed a federal lawsuit seeking an injunction against Trumpet Island Salmon Farm to "cease its ongoing violations and comply with the *Clean Water Act*." The suit alleged that company also failed to apply for and receive a *Clean Water Act* permit.

Further, the federal *Endangered Species Act* listing of wild Atlantic salmon in six downeast Maine rivers also constrained the industry. As a result, fish farms near those rivers had to significantly modify their operations to reduce the risk of harm to wild salmon. For example, Maine fish farmers are now bound by a code of practice for preventing and responding to escapes of farmed salmon into the wild. Each new requirement on the salmon farms to meet legal, environmental or fish health standards brings those operations closer to reflecting the real cost of farming salmon. In a global market, some are questioning whether the salmon aquaculture industry in Maine will survive.[34]

Nova Scotia Industry Profile

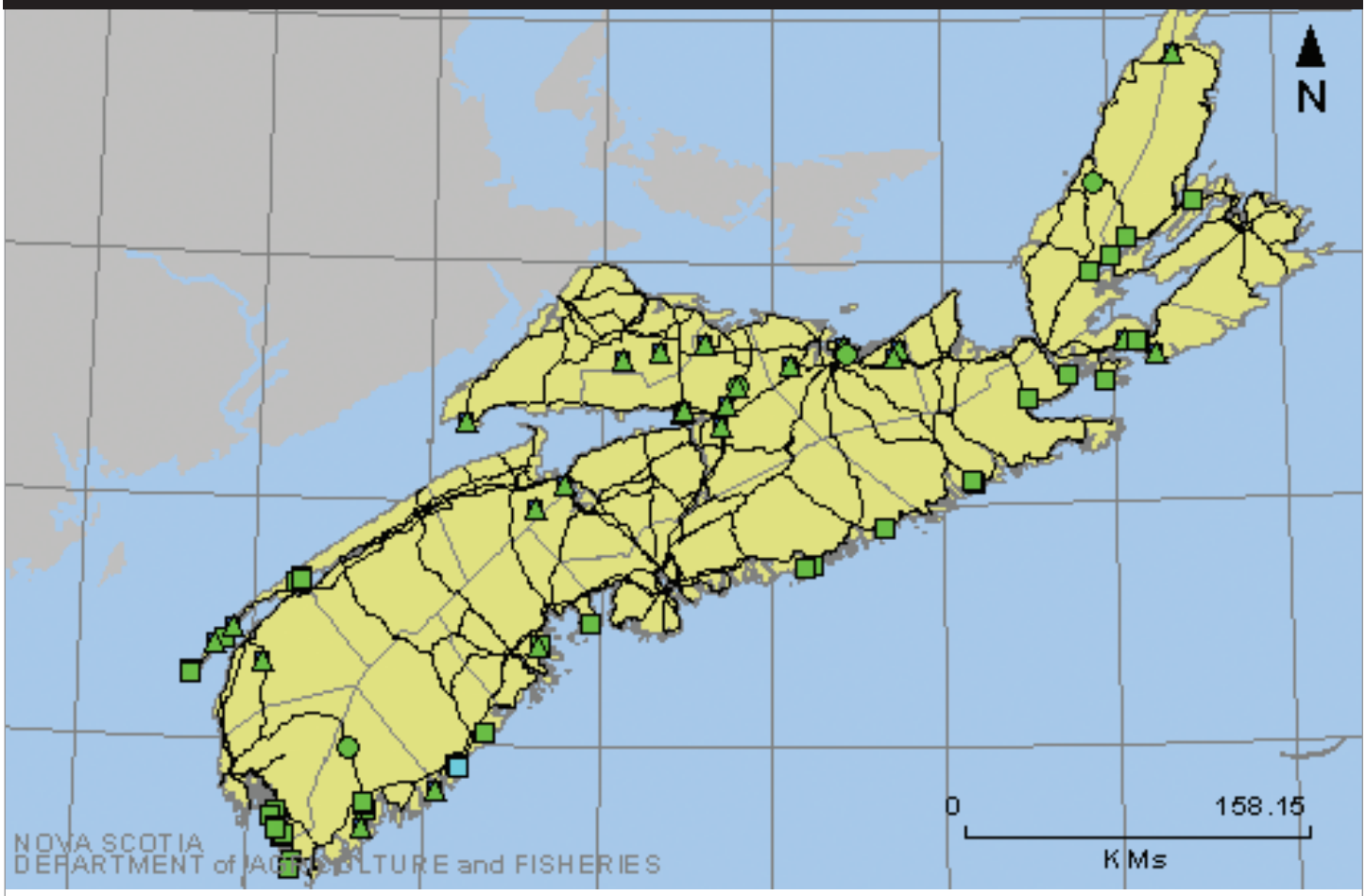
The aquaculture industry in Nova Scotia is more diverse than in New Brunswick's Bay of Fundy, with 35 different species raised on land, and in fresh and salt water. Even so, Atlantic salmon generates the lion's share of production values.[35] It is also a much smaller industry than in New Brunswick. In February 2005, there were 48 marine leases - half as many as in New Brunswick - allocated for Atlantic salmon and Steelhead salmon (also known as Steelhead trout) aquaculture. Four more salmonid lease applications were before the provincial government.

Of the 48 salmonid leases, 16 are in the Gulf of Maine region of Nova Scotia; the rest are along the entire south shore and the Bras d'Or Lakes in Cape Breton. Fifteen of the 48 are owned by New Brunswick companies or have New Brunswick interests. Cooke Aquaculture had four leases in 2005. Other New Brunswick leaseholders are much smaller companies who may have had problems securing additional sites in the crowded New Brunswick waters and so retreated to less developed Nova Scotia to find some space. One of these, Aqua Fish Farms, is the subject of the most intense opposition to finfish aquaculture in Nova Scotia.

Salmon production in Nova Scotia has been much more erratic than in New Brunswick. However, production increases through the 1990s followed by decreases after 2000 reflects a similar trend. Unlike New Brunswick and Maine, ISA has not been a problem in Nova Scotia. Thus production fluctuations and declines more closely reflect market conditions and other conditions particular to Nova Scotia.

In February 2005, the Nova Scotia Department of Fisheries and Agriculture released a discussion document and launched an industry-oriented consultation (with limited outreach to the public or citizens groups) aimed at what needs to be done to further develop the aquaculture industry in that province.[36] It cites several factors that have limited the industry to date, including the longstanding complaint of industry that the application and approval process (federal and provincial) is too burdensome and takes too long, especially the federal environmental assessment process. It also cites a scarcity of suitable inshore marine sites due to water temperature and depths; federal restrictions on the movement and introduction of eggs and fish; public opposition to the siting of finfish cage sites; conditions of lease tenures; lack

Figure 5. Nova Scotia Salmonid Operations



Salmonid (Atlantic salmon, Steelhead salmon, trout) open net pen, inland and hatchery operations, as of July 2007.

of government support programs to reduce the financial risk of disease outbreaks and other catastrophic events; and lack of strategic direction and development support on the part of government.

Further opportunities for development are necessarily constrained by the economic forces at play in the global salmon industry and by the scarcity of appropriate marine sites. According to the discussion document, little opportunity for new sites exists in Nova Scotia's Gulf of Maine zone (from Annapolis Basin to Yarmouth) and around to Shelburne Harbour. On the other hand, it cites significant growth potential along the Eastern Shore, parts of Northumberland Strait and Cape Breton. It also suggests existing leases are under-utilized and should be fully exploited.

Nova Scotia also appears to be focusing on finfish species other than salmon, and wants to "take a lead role in the development of so-called 'whitefish' species such as cod and halibut." There is already a substantial juvenile halibut production effort ongoing, but has apparently been hurt by the changing fortunes of salmon: "The current instability of the salmon market has slowed development of halibut as salmon farmers who may have ordinarily offered cage space for halibut grow-out are now consolidating operations and reducing risk."[37] The document also suggests Nova Scotia growers could take advantage of the emerging organic certification system in North America to command a premium price in the US market.

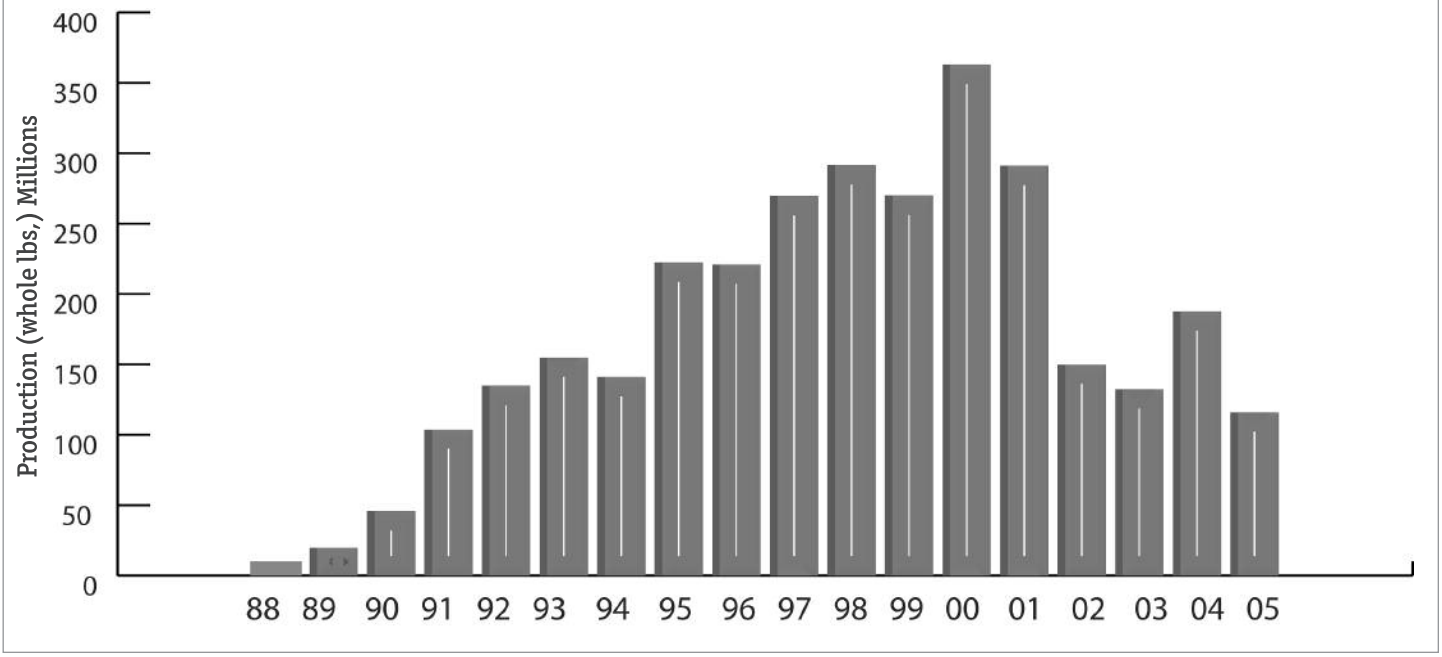
The document makes an interesting observation regarding the development of an alternative to the relatively cheap open net pen system used by marine finfish growers. It notes the potential for expanding the use of more expensive recirculation technology by taking advantage of "a favourable foreign exchange rate or an increase in the market price of a species uniquely suitable to Nova Scotia."

Re-circulating systems have the environmental benefits of capturing and treating wastes and reducing risks from predators, disease transfers, fish escapes and temperature or pollution impacts. Despite these improvements which are necessary for the industry to reduce its ecological footprint, the report issues a word of warning: "It should be recognized however, that conditions conducive to profitable aquaculture using recirculation technology (other than offered by a regional technical advantage) may become a significant disadvantage to Nova Scotia as these systems could then be built anywhere to take advantage of adjacent markets, labour force or processing facilities."[38]

From a sustainability perspective, an appropriately-scaled recirculating aquaculture system located close to markets to minimize transportation would be a vast improvement over the current industrial commodity production model which exploits free ocean waste disposal in rural coastal areas and transports the product long distances to urban markets.

Nova Scotia missed out on the salmon aquaculture gold

Figure 6. Nova Scotia Marine Finfish production in MT

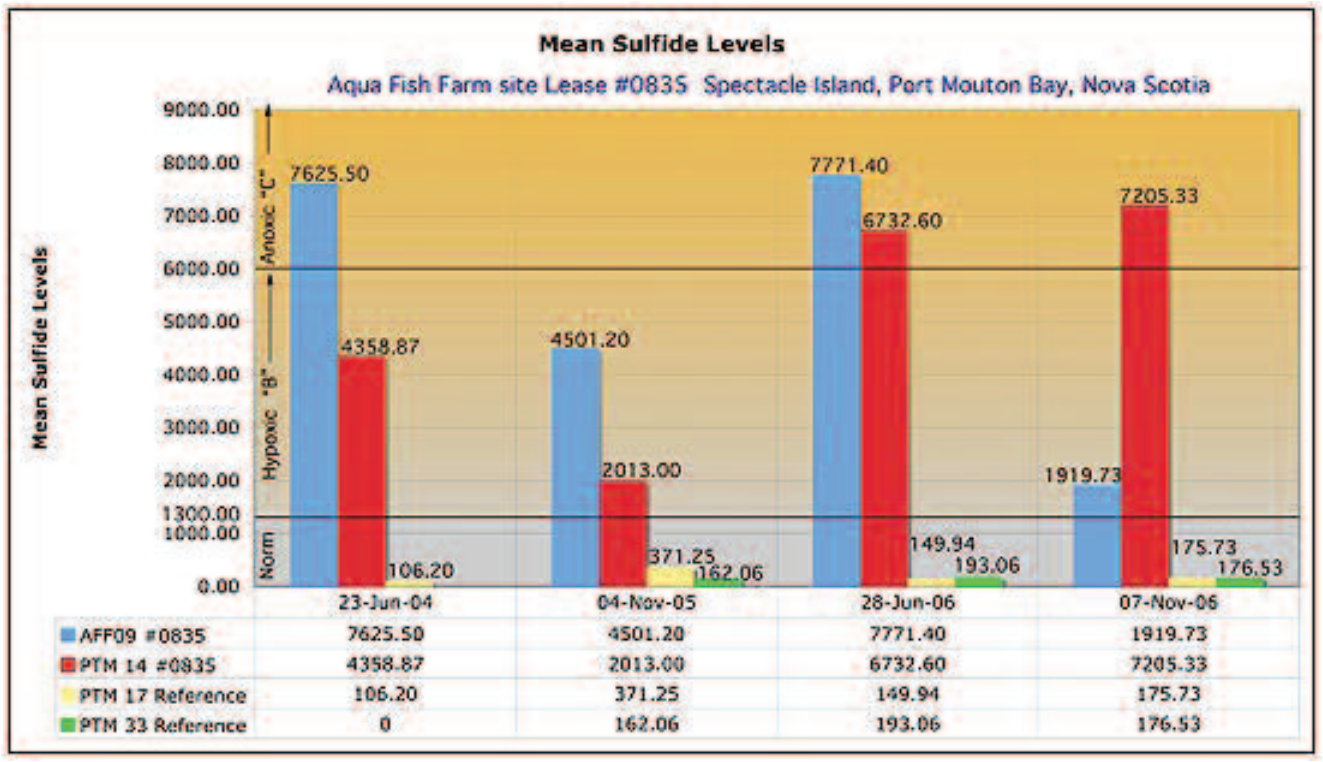


rush of the 1980s and early 1990s when fortunes were made. Trying to position the province now for significant growth in the industry presents problems and opportunities. Only very deep corporate or government pockets can now afford to invest in perpetuating the aquaculture model on which the salmon industry is based, and even these should see the folly of going down that road. On the other hand, the industry and government in Nova Scotia could learn from the salmon experience and deliberately create a new, more economically and environmentally sustainable approach to aquaculture. This would not produce hundreds of millions of dollars in export revenue, but it could provide appropriately-scaled, secure economic development initiatives that would not degrade the environment and would be accepted by communities.

Signs are, however, that the province is taking a similar direction as New Brunswick, at least in its unqualified support for expansion of the industry, even in the face of vociferous community opposition. A protracted battle against a proposed new salmon farm in Port Mouton Bay appears far from being resolved. The company, Aqua Fish Farms, one of seven independent companies in New Brunswick, already operates a salmon farm in that bay. The proposal is for a second farm in the same bay covering 28 ha (70 acres) with 300,000 fish in each of two production areas. Production would be rotated between these two and the 200,000 production on the original site. Overlapping production schedules over the course of a year would see 600,000 fish being raised at one time in Port Mouton Bay.[39]

The existing site, in operation since 1995, provides a window on what a second much larger site might bring to Port Mouton Bay. Sediment measurements of sulphide gas, a by-product of excess loading of organic solids – fish faeces and waste feed – are consistently high, well above the 3000 µm S threshold which DFO considers to create a harmful impact on fish habitat (illegal under the *Fisheries Act* unless "authorized" by the federal minister). In June 2004, June 2006 and November 2006, sulphide levels were above the 6000 µm level at which over 90 percent of the macrofauna under the site would be killed. Even so, the new site application is going through the approval process without the company having to correct the problems at its existing site. An official with the NS Department of Fisheries and Aquaculture was quoted as saying, "the existing site is trouble free," dismissing local concerns and suggesting that opposition will disappear once the site is in.[40]

Figure 7. Spectacle Island Sulphide Levels



Sampling site AFF09 is inside the eastern edge of Aqua Farm's lease site closest to Spectacle Island. Site PTM14 is in the centre of the farm site. PTM 17 is approximately 100 m south and outside of the farm lease. PTM33 is approximately 100 m north and outside of the farm lease. *Source: www.friendsofportmoutonbay.ca. Visited April 30, 2007*

3. The Politics of Unsustainability

Government as Promoter and Regulator: A Conflict of Interest

The federal Department of Fisheries and Oceans (DFO) initiated and supported salmon-related research and development in New Brunswick long before the first salmon farm was ever established. Once the industry began, this support took the form of contract studies, supplying smolts to pioneer fish farmers, scientific expertise, and access to fish health services. DFO also established partnerships with universities and other research organizations to gain access to research grants from other government sources. The federal department of Employment and Immigration Canada (now Human Resources Development Canada) sponsored unemployed people in aquaculture technician training programs that were starting up at provincial community colleges.

The NB Department of Fisheries at the time[41] with its historic mandate to promote the fishing industry in New Brunswick took longer to clarify a role for itself. A 1983 policy made no particular note of salmon aquaculture as an up-and-coming industry, not distinguishing it from several other aquaculture efforts.[42] The provincial government at that point appeared to have no sense of salmon aquaculture's potential and thus was wholly unprepared to consider regulation when the industry took off. Only several years later, well after it had established itself as a major industry in the coastal zone, did the provincial government begin to regulate.

By the end of the first decade, the department became Dept of Fisheries and Aquaculture (NBDFA) and a major promoter and provider of technical support to the industry. Services rendered included engineering assistance with things such as cage design and mooring systems, financial advice, training workshops, fish health and husbandry monitoring, liaison between industry and government departments, and access to an aquaculture veterinarian, lab technologists and hatchery specialists.[43]

Table 1. Funding provided by the Atlantic Canada Opportunities Agency (ACOA) in support of New Brunswick's salmon aquaculture industry from 1985-1996.

Type of Financial Assistance	Amount Financial Contribution ($CND) By Project Type (number of grants)			Total Financial Assistance
	Sea farm development and expansion, feasibility studies, work plans, hatcheries, processing plants	Marketing, research and development, trade shows, conferences	Cage, net, feed, and boat manufacturing, fish health services, fish waste disposal	
Contributions and Grants	10,403,112 (116)	8,547,354 (73)	4,560,468 (45)	23,510,934
Provisionally Repayable Contribution	73,640 (1)		228,240 (1)	301,880
Repayable Contribution	3,856,818 (25)	100,000 (1)	1,256,636 (9)	5,213,454
Interest buy-down Loan	1,485,789 (28)		544,478 (9)	2,030,267
Action Loan	487,500 (2)			487,500
Loan Insurance	2,804,430 (6)			2,804,430
Total Financial Assistance	19,111,289	8,647,354	6,589,822	34,348,465

Dependence on the public purse

The real engine of the salmon gold rush was the sudden availability of government monies to develop the industry. The Atlantic Canada Opportunities Agency (ACOA) was established in 1984 as an agency with an explicit mandate to infuse capital into the economy of Atlantic Canada. As a new economic player, salmon aquaculture became a major project for ACOA, receiving many forms of support for various aspects of the industry.

From 1985 to 1996, ACOA alone pumped over $34 million into New Brunswick's salmon aquaculture industry. Sixty percent of this money was in the form of direct contributions and grants for farm, hatchery, and processing plant expansions, marketing, and research and development. The balance took the form of interest-free and provisionally repayable loans, interest buy-downs, and loan guarantees. In addition, millions of dollars were available through a variety of other federal and provincial initiatives including joint agreements.

Despite the rapid growth of the industry fuelled by this funding, there was still pressure to expand further and faster. In 1988, the House of Commons Standing Committee on Fisheries and Oceans undertook a study to identify barriers to aquaculture development in Canada in order to facilitate growth of the industry. Its report cited jurisdictional issues, poorly designed and uncoordinated financial assistance programs, gaps in fish health and diagnostic services, and the lack of national objectives (a "grand design") as factors preventing the industry from fulfilling its potential.[44] Since then, federal DFO has issued several policy documents which identify aquaculture as a priority of the federal government. Early versions (1991 and 1995) committed the government to removing regulatory barriers as necessary as well as providing research, market and other supports to its development.[45]

Federal support for the industry was cranked up another notch in 2000 when DFO, under then-minister British Columbia MP Herb Dhaliwahl, launched its Program for Sustainable Aquaculture which dedicated $75-million over five years, and $15-million per year thereafter, in the following way:

- $12.5-million in environmental and biological science to improve the federal government's capacity to assess and mitigate aquaculture's potential impacts on aquatic ecosystems;
- $20-million for the Aquaculture Collaborative Research and Development Program under which DFO will partner with industry by jointly funding R & D projects to enhance sector innovation and productivity;
- $22.5-million to enhance the application of DFO's legislation, regulations and policies that govern aquaculture, particularly as they relate to habitat management and navigation.[46]

The program was accompanied by a new Aquaculture Policy Framework with two pillars: 1) increased public confidence in the sustainability of aquaculture development, and 2) increased industry competitiveness in global markets. Notably, the first pillar focuses not on improving the industry's sustainability quotient but on influencing public perception of the industry. The second is very clear as to the department's role as a promoter and enabler of the industry without reference to sustainability issues. Of the new Aquaculture Policy Framework, the DFO website states, "[it] confirms DFO as both regulator and enabler of aquaculture development ... [and] encourages, rather than restrains, responsible aquaculture development." [47]

Government hires embedded lobbyist

The single most important step DFO took as industry enabler was the establishment of the Office of the Commissioner of Aquaculture Development (OCAD) within DFO. OCAD operated from 1998 to 2004; in 2000, its annual budget was increased from $500,000 to $2-million. M. Yves Bastien, who was hired as Commissioner, had very strong industry credentials. Prior to this position, he had worked for the Quebec provincial government as an aquaculture development officer, and then for an aquaculture development association in the Gaspé and Magdalen Islands. He had served on the boards of directors of the Aquaculture Association of Canada, the Canadian Aquaculture Industry Alliance, and the World Aquaculture Society.[48]

Initially, M. Bastien's job was to implement the 1995 Federal Aquaculture Development Strategy. To do this he was to "bring together all appropriate federal government resources, lead required regulatory reforms, and work with the provinces to develop a vibrant, environmentally sustainable aquaculture industry."[49] His mandate, renewed in 2001, was to "identify an appropriate federal role in aquaculture...taking into account the Federal Aquaculture Development Strategy, current federal policies and budget orientations, and the needs of the sector (including advocacy and developmental support)." In the Preface to his final report as Commissioner, it says of the position of the commissioner vis a vis the industry, "The Commissioner was asked to be the champion for aquaculture within the federal government...".[50]

As the government-funded industry champion, M. Bastien became a spokesman for the industry both inside and outside government, making speeches to various audiences

and appearing before Parliamentary committees as an industry advocate.[51] Meanwhile, his office produced three major reports during its six-year lifespan. The first was a review of Canadian legislation and regulations governing aquaculture.[52] The second, a "vision" document, was an unapologetic promotional piece for the industry which ignored or downplayed any and all significant issues affecting the industry.[53] The third was M. Bastien's recommendations on how the federal government can further 'enable' aquaculture development.[54] Minister of Fisheries and Oceans Geoff Regan released this last report on March 1, 2005 with an invitation to "Canadians" to make comments on it by March 12, an impossibly short period of time, especially given that no lead time for the release was given.

One news report immediately picked up on the essence of the report. The headline in the *Moncton Times & Transcript* read, "Feds urged to ease regulations for fish farms," with the tag line, "Report calls for allowing dumping waste in ocean, as well as private ownership of the sea." Reporter Campbell Morrison wrote, "At the end of his mandate, the federal government's aquaculture commissioner is seeking a dramatic easing of environmental regulations and the introduction of private property to allow the industry to grow five-fold in the next decade." [55]

The Conservation Council of New Brunswick (CCNB), as well as environmental groups in British Columbia, immediately wrote the Minister to ask for an extension on the deadline for comments and set about to analyze the recommendations. The Minister made no response to this request. CCNB subsequently submitted an eight-page brief to the Minister, critiquing key underlying assumptions in the report as well as specific recommendations, and requesting that the Minister "exercise due diligence to make sure all the implications of the report's recommendations are fully discussed in open and transparent fora before taking any action to implement recommendations that will have consequences beyond the aquaculture industry itself."[56]

CCNB was particularly concerned about the very issue identified in the *Times & Transcript* story and disagreed with all the substantial recommendations regarding environmental regulation. The effect of those recommendations would be to exempt the aquaculture industry from the current provisions of the *Fisheries Act* which prohibit the discharge of deleterious substances into water inhabited by fish, as well as the alteration, degradation or destruction of fish habitat unless under authorization of the Minister (such authorization generally stipulates a compensation program). Such exemption would provide aquaculture with special status in Canada, since all industries are subject to the *Fisheries Act*. CCNB wrote, "no person, organization or company is exempt…from the provision to protect fish habitat. To suggest that this requirement is too big a burden for this industry is to continue the disturbing expectation of this industry that it deserves special treatment. It doesn't. If it is so commercially important with such a potential for economic growth, then it must be mature enough to shoulder the responsibility that comes with doing business in publicly-owned waters and shorelines."

On the other hand, CCNB supported the proposal that responsibility for development and promotion of the industry move to Agriculture Canada. That would address the inherent conflict of interest within DFO that arises with the dual responsibility of industry promotion and regulating the industry's impact on the marine environment and fisheries resources. When he released the report, Minister Regan rejected this proposal. CCNB responded in its brief, "We understand the Minister of Fisheries has already rejected this scenario. It would mean, of course, a transfer of resources from DFO to Agriculture Canada, and it is contrary to departmental culture to willingly let go of dollars and personnel. However, the current arrangement is inhibiting in many ways, and in the end undermines DFO's primary responsibility for the marine environment. It needs to be changed." [57]

Minister Regan released his response to M. Bastien's report on March 30, 2004 without exercising the due diligence of public consultation called for by CCNB.[58] He said DFO would:

- Make organizational and resource changes…to ensure aquaculture is **more** [emphasis added] of a priority.
- Create an enabling regulatory environment so the industry can succeed sustainably. A "smart" policy and regulatory framework will be implemented that first and foremost upholds DFO's mandate to safeguard the environment and wild fish stocks in a manner which supports the industry's performance and competitiveness.
- Pursue stronger collaboration with federal and provincial partners to bring about an integrated governmental response to the emerging needs and priorities of the aquaculture industry, such as food safety, traceability, business risk management[60] and fish aquatic animal health.
- Strengthen its efforts to raise public and consumer confidence about food safety and protecting the environment.[61]

The immediate organizational change made by the Minister,

to create an Aquaculture Management Directorate with Yves Bastien as its first executive director, pleased the New Brunswick Salmon Growers Association. In response to M. Bastien's report, Nell Halse, then general manager of the association, called for the Minister to "maintain an 'advocate' for the industry." She specifically complained that "fish farmers are 'under attack from well-financed opponents' and that it needs Ottawa's help in fighting back."[62]

CCNB's submission received support from the Chair of the House of Commons Standing Committee on Environment and Sustainable Development. MP and former Environment Minister Charles Caccia wrote to Minister Regan, stating his support for stronger, not weaker, environmental regulation of the industry. He wrote, "In the correspondence you received...from the Conservation Council of New Brunswick, they provide critical insight into the Commissioner for Aquaculture Development's report....I urge you to consider favourably their recommendations referring to s.35 and s.36 of the *Fisheries Act*. As the federal government is responsible for the long-term sustainability of this industry, I hope you will adopt the priorities recommended by the Conservation Council." [63]

Minister Regan's response to Mr. Caccia dismissed the environmental concerns expressed. He wrote, "While some of the letters I received from the public in March expressed grave concerns, I can assure you that there were also a number of letters praising the Commissioner's Report, his recommendations and the economic prosperity that the aquaculture industry brings to many coastal and First Nations communities on both coasts." He reiterated DFO's determination to be the lead development agency for the industry "while upholding our conservation mandate." He also restated the department's goal "to increase the public confidence in the sustainability of aquaculture by ensuring it is an environmentally sustainable, socially responsible and economically viable industry...able to compete on world markets." He closed by acknowledging that "some decisions have already been made... [but] for others we will be seeking to obtain the views of Canadians."[64]

The Conservation Council received no response from Minister Regan to its submission and there never has been any subsequent effort by DFO to seek "the views of Canadians" on the Commissioner's recommendations.[64]

Regulation: Half-hearted at best

With both the federal and provincial governments heavily promoting, supporting and subsidizing the growth of salmon aquaculture, neither has been in a position to credibly regulate the burgeoning industry. For the first 10 years (1979-1989), finfish aquaculture was virtually unregulated. Individual farms required cage site approvals and licences, which were administered by two provincial government departments. The Department of Natural Resources and Energy (DNRE - now Dept of Natural Resources, DNR) granted leases within the coastal zone (submerged Crown land) for sea farm operations. The New Brunswick Department of Fisheries granted licences to operate. No environmental approvals were required by either federal or provincial environment department.[65]

The only legislation directly relating to the industry was the federal *Fisheries Act*, which prohibits the "harmful alteration, degradation or destruction" (HADD) of fish habitat, and the release of "deleterious substances" into waters frequented by fish. However, until recently DFO had only operated in an advisory capacity to the provincial government in final site approvals, and has never denied permission to site an aquaculture operation where it might harm fish habitat once a site had received provincial approval. Nor has it laid charges against a farm for releasing substances 'deleterious to fish' into the water column.

In 1989, NBDFA was given full jurisdiction over the industry. An interdepartmental protocol was signed transferring responsibility for leasing aquaculture sites from DNR to DFA. In addition, a federal-provincial Memorandum of Understanding (MOU) gave DFA lead responsibility for aquaculture development and the licensing process. With that MOU, federal fish habitat protection responsibility was abdicated to provincial discretion. DFO assumed an advisory role to DFA in siting decisions and a research role responding to a variety of industry demands and establishing monitoring protocols.

This left DFA with dual and conflicting roles of promoter and sole regulator of the burgeoning salmon aquaculture industry, just like its federal counterpart. The Aquaculture Site Evaluation Committee (ASEC) was established comprised of representatives of federal and provincial government agencies to provide advice on leasing marine sites. As a member of this committee, DFO has recommended against several sites based on fish habitat considerations, but with final authority to approve sites, the provincial Minister of Fisheries and Aquaculture has on occasion placed politics above the advice of this committee. In spring 1997, for example, most of the site applications the committee recommended against were in fact approved by the Minister. DFO took no steps to exercise its jurisdiction to protect fish habitat by vetoing these approvals. DFA also set up the Aquaculture Environmental Coordinating Committee (AECC) comprised of representatives of the salmon industry and federal and provincial government agencies to coordinate

environmental research and monitoring activities for salmon farms. Repeated requests to gain representation on these committees by environmental, fisheries and landowner groups have been consistently denied.

New Brunswick's *Aquaculture Act*

In 1988, a new piece of legislation was enacted to give DFA the legal framework and authority to regulate the industry. The impetus for the *Aquaculture Act* came largely from the onslaught of applications for new farm sites and the absence of rules for the orderly development of the industry. The *Act* was introduced in the Legislature in December of that year, 10 years after the first fish went in the water. By this time, 52 farms were operating and producing fish valued at nearly CDN$75 million. Despite the urgent need for regulation, the Act did not come into effect until October 1991 when the accompanying regulations were finally approved by an Order in Council.

The *Aquaculture Act* includes conditions to which licences may be subject, such as measures to prevent disease, parasites, toxins or contaminants spreading to other aquaculture sites and to prevent environmental degradation. Actual requirements of licensees are spelled out in each site licence and regulations to the Act. Per site fish density was limited to 18 kgs per cubic meter of cage space (four to five full-grown salmon or many more smolts). Each site was assigned a specific allowable production limit (APL) based on a formula which takes into account several parameters related to physical site conditions and lease size. Eventually, licensees were required to collect and submit environmental monitoring data to DFA, although the regulation did not establish minimum standards to be met. Licensees were also required to maintain accurate records and submit reports on the incidences of diseases and the types and amounts of any chemotherapeutants applied at each site.[66]

Figure 8. Simpsons Island aquaculture site.

Credit:CCNB.

Section 29 of the *Aquaculture Act* has very broad confidentiality provisions. It covers any information submitted to DFA by the aquaculture companies in the process of a site application, renewal or amendment, as well as any "books, records, accounts" or any other documents required to be kept by the Act. This confidentiality provision has been used to refuse release of aquaculture site applications for public review, even though the public is invited to submit written comments on any proposed site. The act gives the Minister the discretion to disclose such confidential information under certain circumstances, including "to any person in the course of consultation, public or otherwise, undertaken to any application under this Act..."[67] Presumably, this discretion provision was made in the interests of fair and transparent public participation and full disclosure of activities licensed for public waters. Yet it has never been exercised and requests for site applications, disease reports, and such documents are consistently withheld by the department. Requests through the provincial *Right to Information Act* are also denied and the appeal process has upheld that denial. In the midst of a particularly heated siting controversy in 2003, a small overture was made to citizens. The department encouraged the company to release its application directly to those who request it. Since then, other companies have done the same, yet the government's policy of non-disclosure remains intact despite ongoing pressure to amend the *Aquaculture Act's* confidentiality provisions.

The exception to this rule is environmental monitoring data. In 2002, when responsibility for environmental regulation was transferred to the Dept. of Environment under the *Clean Environment Act*, the industry's confidentiality protection was inconsistent with the department's practice with respect to monitoring data from other industries. Initially the department released aquaculture monitoring data only once it was requested under the *Right to Information Act*. Pressure by the Conservation Council eventually resulted in this pretense being abandoned and the data is now available on request.

The Regulations to the *Aquaculture Act* empower the government to refuse to issue a lease or occupation permit, and to refuse to issue, renew or amend an operating license if the following conditions exist: conflict with other fishery

activities; conflicts with other resource users; interference with ecologically or environmentally sensitive areas; or unacceptable environmental risks. Over the years, however, very few site applications have been rejected despite frequent opposition by landowners, commercial fishermen, conservation organizations, and even other government departments. A particularly contentious site at Round Meadows Cove near Chance Harbour was approved in 2003 against the strong protests of fishermen, local residents and conservation groups. According to DFO scientists, this site, adjacent to a nature preserve owned by the Nature Conservancy of Canada, is important habitat for sea urchins and lobster, and at least a portion of the lease area is depositional, that is, it is poorly flushed and therefore has the potential to accumulate solid wastes from the fish farming operations.

New site allocation rules

As the industry expanded through the 1990s, public concerns and conflicts with commercial fishermen and landowners also expanded. This led to the launch in 1997 of a review of how sites are allocated. The review hardly got off the ground with very preliminary consultations when a new disease outbreak, eventually identified as infectious salmon anemia (ISA), diverted both government and industry attention from policy matters.

According to NBDFA, the review was launched because the 1992 policy was scheduled to be revised after five years. But the department also cited a number of "challenges" facing the industry which needed to be addressed in the context of site allocation. Also noted was the fact that the industry was "demonstrating interest in more 'open ocean' or 'offshore' sites," and that the department was receiving a growing number of applications for sites to grow finfish species other than salmon. The existing policy provided little guidance on these issues.[68]

Little space was left for new sites in the coastal zone and conflicts with commercial fishing interests were intensifying, especially with the herring industry which was losing irreplaceable weir sites to salmon farms. Salmon growers were asking for larger operations so they could achieve economies of scale, a response to depressed prices due to stiff competition in the marketplace. They also opposed the 1992 policy of favouring new entrants for the allocation of scarce farm sites. The imperative, the industry said, was to stabilize the situation for existing companies by allowing them to expand and consolidate rather than increase the number of companies and therefore the competition for space and markets.

At the same time, by 1997 fish mortality due to disease had increased from less than five percent in the 1980s to an average of 20 percent across the industry. [69] Epidemics of sea lice had ravaged many farms in the mid-1990s, and the typical salmon farm diseases (i.e. hitra, furunculosis) were chronically present. But this staggering 20 percent figure did not account for the outbreak of infectious salmon anemia (ISA) which was just beginning. Fish disease, including parasite (sea lice) infestation, is generally understood to be a function of several parameters including stress on the fish (e.g. overcrowding), environmental quality (e.g. dissolved oxygen content of the water column), and the presence of prime conditions for the spread of disease vectors (e.g. many hosts within close proximity).

The consultation process on the new site allocation and administration policy stretched out over three years while the limited resources of NBDFA were tied up with a new disease on the block, ISA. The existing problems in the industry and environmental conditions indicated the failure of the development and management framework that directed the industry growth to date. In its submission to the policy review, CCNB stated government regulation needs "to acknowledge an ecological bottom-line: industry is first constrained by nature and then by the market. It is clear from the current state of New Brunswick's salmon aquaculture industry that neglect of ecological considerations has resulted in natural constraints to growth, and at the same time a deterioration of the environment in which the industry is located."

CCNB called for a moratorium on any new site approvals and expansions of existing sites until a new policy was adopted, existing sites to be modified to meet requirements of a new policy, specific problem areas where environmental damage had been done to be remediated, disease problems to be solved, new processes to be put in place to identify potential new sites, and research to be initiated to gather baseline oceanographic and biological information to support new site allocations.[70] CCNB's call for a moratorium was explicitly supported by the federal Minister of Fisheries and Oceans of the day, Hon. David Anderson.[71]

The Province did impose a moratorium of sorts on new site approvals during the period of the review. Officially, new sites were approved only as emergency or temporary sites as the industry struggled to eradicate, and failing that, to contain, the ISA virus. Regardless, from 1997 to 2000 when the final site allocation policy was released, farmed salmon production in the Bay of Fundy grew from 18,585 MT to 29,100 MT, a 57 percent increase even as millions of fish were culled for ISA control and a moratorium was in place.

Compliance and enforcement

By the time of the policy review, it had become common knowledge that many salmon farms were routinely over-stocked (the licence stipulates the 'allowable production level' or APL for each site). It was also understood that overstocking was a contributing factor to disease outbreaks and transmission, as well as environmental degradation. Yet NBDFA made no attempt to enforce the conditions of licence. As disease and sea lice ravaged the densely-packed sites, enforcement became a key issue in the site allocation policy review.

In his comments on the draft policy, Dept of Fisheries and Oceans Maritime Region director-general Neil Bellefontaine wrote, "This is an area we believe deserves priority attention....[I]t is essential that an administrative system is in place where environmental monitoring and site operation surveillance is directly tied in with compliance of site licence conditions and that there is an enforcement strategy in place to deal with instances of non-compliance or when requested corrective measures are not implemented. The development of a joint enforcement protocol between our agencies detailing respective roles, responsibilities and accountability is needed. I believe the time has arrived for us to address this requirement."[72]

Yet the final policy document only said that the Province would monitor, inspect and audit to make sure standards are being met, and that the Province maintains the right to suspend licences and leases to ensure compliance. It also invoked the "full range of actions available under the *Clean Environment Act* and *Clean Water Act*" to get compliance.

Regarding the problem of overstocking sites, the policy states that the government will audit all fish movements between hatcheries and marine sites. Presumably this would be facilitated at least by invoking for the first time a section of the federal *Fisheries Act* that requires introduction and transfer permits for the movement of fish. As part of the ISA management plan, salmon growers require (as of 1998) a federal permit prior to moving smolts from hatcheries to grow-out sites.[73] This is a far cry from a joint federal-provincial enforcement protocol as requested by DFO. Nor, at the time of the policy release, did NBDFA have the capacity to carry out the audits, inspections and enforcement actions.

In 2003, 12 years after the *Aquaculture Act* and Regulation came into force and three years after the release of the new site allocation policy, NBDFA (now NBDAFA) finally established the Licensing and Compliance Branch, which includes a Compliance and Enforcement section. By fall 2003, five charges had been laid against companies alleged to be non-compliant with fish eradication orders for disease control. The operation of the enforcement section was called into question in 2004, however, when two of the three head office staff went on long term disability leave and were not replaced.

Finally a New Policy

In October 2000, four years after the review was announced, NBDFA released the final Bay of Fundy Marine Aquaculture Site Allocation Policy.[74] The policy laid the groundwork for restructuring the industry to address

Figure 9. Aquaculture site being serviced by barge.

Credit:CCNB.

disease problems and "improve environmental stewardship." The two pillars of restructuring were to move the industry towards a single year class management system and to do this within a bay management area framework.

The salmon farming area of the Bay of Fundy was divided into zones called **Aquaculture Bay Management Areas** (ABMAs). Aquaculture licensees within an ABMA were to develop a "bay management agreement" which would establish operating standards with respect to fish health protocols to which each fish farm would adhere. The Province required a bay management agreement before any new site applications, boundary changes or production increases would be approved. (This effort was misguided since the ABMAs were not established based on oceanographic conditions, which would dictate the movement of disease vectors or parasites throughout the area. In 2006, this entire system was redrawn based on actual ocean current data collected by DFO).

Single-year class management - that is, only one generation of salmon on a site at any time – was determined by government and industry to be the single most important measure in controlling disease outbreaks and transmission. The new site allocation policy mandated that only one year class or generation of salmon would be raised in a particular ABMA; all farms within an ABMA would stock their sites and harvest them in the same year, while allowing a 20 percent holdover on any one site to account for harvesting schedules. In force by spring 2001, single year class management meant that each farm site would require a companion site in a different ABMA in order to have a continuous crop of salmon under cultivation. This generated a new phase of site applications outside the existing fish farming areas. To accommodate this, the new policy stated that until this restructuring was complete, priority for new sites would be given to companies that require a second site to meet the single-year-class requirement. This priority quickly became lip service, with most of the new sites approved post-2001 going to well-established companies with multiple sites.

In response to a concerted lobby by the herring weir and sardine processing industry, the new policy established herring exclusion zones designed to protect the remaining important herring weir locations from encroachment by or conversion to salmon farms (many herring weir sites had already been lost to salmon farms). This did not remove existing salmon farms from those exclusion zones, nor did it prohibit boundary expansions or production increases on existing salmon farms with the exclusion zone. However, it did prevent new sites from being established within that zone.

Because weirs are a passive trap technology, they depend on herring swimming into them. The herring industry wanted important herring migration routes included in the exclusion zones because herring movements are very sensitive to noise, light and other disturbances including the presence of fish oil slicks generated by the salmon farms. Earlier research suggested that herring catches declined in weirs after salmon farms were established in close proximity to them.[75] Nonetheless, herring exclusion zones did not extent to migration routes. Nor were the exclusion zones cast in stone. The policy allows for "modifications and refinement" based on consultation with the aquaculture and commercial fisheries sector.

The 2000 site allocation policy was only a half measure. It did not establish a minimum fallowing period for any sites, nor did it increase the minimum separation distance of 300 m between farms. This is much less than salmon farming regions in British Columbia, Norway and Scotland which maintain at least a one kilometre distance between farms. Finally, the policy did not establish maximum production levels for particular aquaculture bay management areas based on oceanographic and environmental conditions.

By 2006, the entire policy had become irrelevant. It had failed to control disease or improve environmental conditions. It also failed to stabilize the industry financially. While a few new sites had been approved in the intervening years, all but one had gone to companies with many sites. The most recent was the Haley's Cove site approved in May 2006 for Cooke Aquaculture which at the time controlled at least 60 sites and could not justifiably claim to need the site to achieve year-class separation.

After many business failures and intense consolidation, the structure of the Bay of Fundy industry was once again on the table. At the time of writing, aquaculture bay management areas have been completely redrawn based on oceanographic data that DFO finally decided to collect. This is to support a new three-year rotation schedule, rather than the two-site rotation set up with the single year-class requirement. The three-year rotation incorporates a fallow period of from six to twelve months depending on hold-over provisions. The primary benefit of this will be to give the company some flexibility on harvest schedules depending on market conditions. It is also expected to assist in breaking disease or parasite cycles and improving environmental conditions. However, site conditions are so variable that the disease and environmental benefits cannot be assured.

Federal environmental impact assessment

While DFO avoided its direct responsibility to enforce the federal *Fisheries Act* until 2006, the federal government became more of a player in the environmental management of the industry in 2001 when DFO acknowledged that marine aquaculture operations were subject to the *Canadian Environmental Assessment Act* (CEAA), a statute that had been in place since 1995. CEAA is triggered if an "undertaking" requires a federal permit to proceed. Marine aquaculture sites require a permit under the *Navigable Waters Protection Act* (the Coast Guard issues such permits to ensure that marine navigation is not impeded by the development). Therefore, marine aquaculture sites are subject to federal environmental impact assessment.

CEAA provides for varying degrees of assessment depending on the type or significance of the project. Aquaculture projects are required to undergo the least rigorous assessment, that of a screening. Screenings of projects are carried out by the department that has jurisdictional responsibility for the project (referred to as the "responsible authority" or RA), in this case DFO.

DFO uses an objective rating scale to determine whether the project could result in a HADD (harmful alteration, disruption or destruction of fish habitat). If no HADD is expected, the application is approved. If a HADD is possible, the proponent is asked to modify the project to mitigate the effect. Theoretically, if the effects cannot be mitigated, DFO would have the authority to deny approval of the application. However, this would not automatically result in a denial by the Province of a licence to operate, since there is no direct link between the federal environmental assessment process and the Approval to Operate issued by the provincial environment department.

The Bay of Fundy Marine Aquaculture Site Allocation Policy makes no specific reference to federal requirements, except the blanket statement that "all approved sites will be required to meet applicable federal and provincial legislative and regulatory requirements." During the consultation on the 2000 policy, DFO requested the following language be included to link the provincial and federal approval processes: "The Province will only approve a marine site for aquaculture development where Fisheries and Oceans supports aquaculture development and the proposed operation will have no significant impact for the commercial fishery harvest or on fish habitat."[76] This language did not appear in the final policy.

The application of the federal environmental assessment process has been a dismal failure. The industry complains there is too much duplication between the provincial site application process and the federal environmental assessment process. The time lines for the respective reviews are also frequently out of step, with the federal assessment taking longer and therefore delaying the start-up of new sites. Reform of the environmental assessment process was one of the top priorities identified by the industry in the final report (2004) of the Commissioner for Aquaculture Development to the Minister of Fisheries.

From the public perspective, the federal environmental assessment is equally frustrating. In a screening process, the responsible authority has no obligation to engage in public consultation, although notice of a review pursuant to the *Navigable Waters Protection Act* is published in newspapers and written comment invited. Deadlines for comments are generally 30 days from the time of the notice. Within that time frame, information provided by the proponent to DFO for purposes of the screening is rarely available to the public, nor are any internal documents provided by government reviewers.[77] Thus the public has been expected to comment on the application without seeing it, and without an opportunity to review the screening document prepared by DFO staff. The futility of the process is underscored by the fact that the provincial government can still issue a licence for a site without the federal environmental assessment being completed, and that DFO has no authority to veto a licence on environmental grounds. With these constraints, it is difficult to characterize the environmental assessment as anything more than a toothless paper exercise.

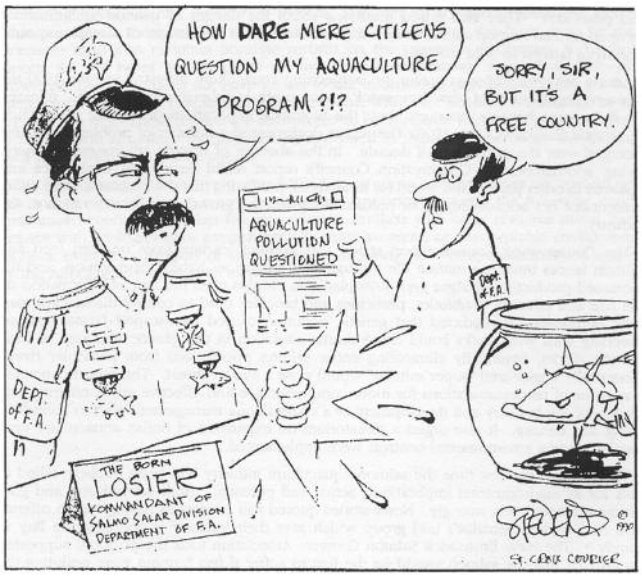
4. Environmentally Unsustainable

After a decade of aquaculture development in New Brunswick during which time the number of sites and production levels increased substantially, the public became concerned about issues such as waste discharges from aquaculture operations, loss of coastal habitat, and the use of antibiotics and pesticides. They also raised questions about the impacts of escaped farmed salmon on wild salmon stocks.

In June 1990 the Conservation Council of New Brunswick, jointly with Fundy Weir Fishermen's Association and the Charlotte County Clamdigger's Association, released the first public report on the ecological implications of sea cage aquaculture in Atlantic Canada documenting a number of problems that had emerged over the previous half decade. In the absence of area-specific environmental monitoring information, the Conservation Council's report referenced experience and research in other parts of the world for its analysis, predicting that the problems were either present but not acknowledged, or likely to develop given the growth and concentration of the industry.

The report stated that nutrient loading from uneaten feed and salmon faeces threatens marine life through eutrophication, habitat degradation, and the increased production of algae. It also cited the lack of information on the fate and effect of antibiotics, pesticides and biocides used to control disease and parasite outbreaks. It predicted that genetic pollution caused by escaped farmed salmon breeding with wild stocks could cause drastic alteration in the genetic make-up of local salmon stocks, potentially eliminating entire wild salmon populations from particular rivers. Genetically engineered "super salmon" would pose a similar threat. The report contained a number of recommendations for more comprehensive and effective environmental regulation of the industry and development of a coastal zone management plan to control its siting and density. It also urged a moratorium on expansion of finfish aquaculture until legally binding environmental controls were implemented.[78]

Figure 10. St. Croix Courier, July 1990



This marked the first time the salmon aquaculture industry had been publicly called to task for its environmental impact. Both the industry and government reacted strongly. News stories quoted fish farmers as having "taken offence at a [sic] environmentalist's [sic] group which says their industry is polluting the Bay of Fundy." The New Brunswick Salmon Growers Association, supported by DFA, responded that the salmon would be the first to suffer if fish farming were polluting the ocean, ignoring the fact that disease problems that had already emerged at several cage sites (see Disease Problems Unmasked).[79]

Even the Minister of Fisheries and Aquaculture stepped into the fray. Hon. Denis Losier was quoted as saying the claims concerning the effects of aquaculture on the marine environment were "unfair". In a prepared statement, the Minister said he wished to "set the record straight before New Brunswick's aquaculture industry is unjustly depicted as destroyer of the Bay of Fundy marine environment." He stated, "In setting up the aquaculture industry we have consulted various industry, government, scientific and local groups to ensure the orderly development of aquaculture would take place within a sustainable development framework."[80]

Not until 1997, however, was a scientific overview of ecological issues in the Bay of Fundy prepared. A scientific workshop on Bay of Fundy issues issued a succinct summary of problems resulting from fish farms which confine large numbers of fish in a very small area releasing a continual and large quantity of particulate and dissolved organic waste into a small area over an extended period.

There is concern that the added nutrients could foster eutrophication and possibly trigger microalgal blooms in the vicinity of the cages that would have lethal or sublethal effects on fish stocks. It has indeed been possible to demonstrate significant localized declines in oxygen and increases in ammonia concentration in the immediate vicinity of fish cages, particularly in situations where tidal

flushing is restricted. The impacts of aquaculture wastes accumulating in benthic sediments are thought to be potentially more serious... The decomposition of these accumulated organic wastes may result in a negative redox potential in sediments, release noxious gases such as ammonia, methane, carbon dioxide and hydrogen sulphide, and significantly increase the biological and chemical oxygen demand in the sediment and also in the overlying water....[81]

Since 1997, the understanding of the impacts of discharges, both solid and dissolved, has continued to evolve. Every 1000 tonnes of salmon produces 566 kg/day of faecal waste,[82] 90 kg/day of nitrogen, and 9 kg/day of phosphorus.[83] A total annual production of 35,000 tonnes of salmon, therefore, produces 7,200 tonnes of faecal waste, more than 1000 tonnes of nitrogen, and 115 tonnes of phosphorus. This is discharged directly into the marine environment through the open net pens. To put this in the context of human sewage production, aquaculture discharge of faecal solids into the southwestern Bay of Fundy in 2005 was equivalent to that of 93,450 people; nitrogen discharge was equal to 437,500 people; and phosphorus discharge was equal to 63,000 people.[84] The population of Saint John, New Brunswick, which by 2007 still discharged 46 percent of its sewage raw into Saint John Harbour and its tributaries, is 68,000.

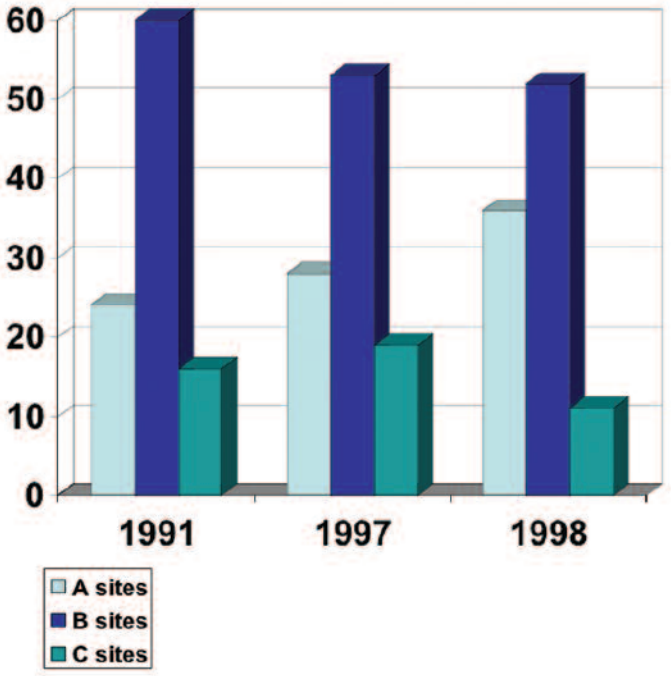
Environmental Monitoring in the Bay of Fundy

Shortly after CCNB released its critical report, the NB Dept of Environment (NBDOE) requested to monitor existing cage sites for certain environmental parameters. This request was granted and funding provided for a limited three-year program beginning in 1991. Meanwhile, the Huntsman Marine Science Centre, a university-based research centre, presented its preliminary results of a two-year study on the environmental effects of aquaculture on bottom (benthic) habitat under four salmon farms at the 1991 annual meeting of the Aquaculture Association of Canada in St. Andrews, New Brunswick.[85] The study suggested that impacts on the bottom were limited to the area immediately below the cages and no effects were detected 50 meters from the cages. However, other studies at the time had demonstrated that benthic impacts can be measured up to 150 meters away from cages and up to ten times larger than the farming area depending on the scale of farm operation.[86]

The Huntsman study did confirm what had been reported in a number of other studies that there was an increase in the number of *Capitella capitata*, a polychaete worm used as an indicator of organic enrichment in marine environments. At one site, the number of *Capitella* rose from a seasonal low in summer of approximately 3,000 worms per square meter beneath a site to a seasonal high of almost 20,000 per square meter by the fall. Perhaps the most significant result of the study was how rapidly the benthic community changed with the onset of farming. Despite the limited scale of operation at one site, researchers found significant reductions in species diversity and increases in bacterial biomass within two months of commencing operation.

The first year of monitoring by the DOE (1991) found that reliance on the high tides and strong currents of the Bay of Fundy to supply clean, oxygenated water and to flush out oxygen-depleted water and soluble waste products had been misplaced. Despite what had been often described as a "veritable river flowing through most sea cages", 37 of 48 sea farm sites monitored in 1991 had moderate to high environmental impact ratings (16 percent were highly

Figure 11. Percentage of Sites Reporting According to 1997 Classification System



"A" sites were considered as having a low impact on the sea floor beneath the fish farm. "B" sites were considered as having a moderate impact on the sea floor. "C" sites were considered as having a high impact. From a report received from the New Brunswick government under a *Right to Information Act* request. The report notes a great variance in "B" site conditions, ranging from borderline "A" sites to borderline "C" sites.

impacted and 60 percent were moderately impacted).[87] Noxious gases released from the sediments under cage sites was reported at all eight high impact sites and at 10 percent of the 29 sites that had moderate impacts. Degradation of the sea floor was caused by "gradual accumulation of excess organic matter [excess feed and fish faeces]. The result was an annual enrichment of the seabed, followed by an increase in bacterial activity and reduction in suitable habitat under cages for some native species."[88]

Environmental monitoring in 1992 and 1993 had similar results. Of the 34.6 hectares of seabed directly impacted by sea cages (immediately under the cages plus a 10 meter zone of influence around each cage site, an insufficient distance according to other studies[89]), eight sites encompassing 8.3 hectares, nearly one quarter of the area, were classified as heavily degraded. At heavily degraded sites, impacts included "moderate to heavy gas bubbling, the absence of fish, invertebrates and sediment-dwelling organisms, the accumulation of fish faeces and fish feed on bottom through a tidal cycle, or thick bacterial mats, and in severe cases, anoxia." Conditions in the remaining area ranged from "slight enrichment to conditions which limit

Description of Environmental Conditions under Salmon Farms

"...Souring occurs when there is too much organic input from cage activities (fish feed, waste) for the micro and macro organisms in the sediment to handle. The result is that the sedimentary bacteria are overloaded and the less toxic forms are replaced by bacteria [Beggiatoa sp.] that use up the overlying water. They also produce toxic gases (e.g. hydrogen sulphide, methane) as by-products which not only exclude other life forms from the seafloor but can disrupt the caged fish above. This advanced seafloor degradation occurs at sites which experience weak currents, a long tidal slack period and are situated in a relatively shallow location. Other signs that the seafloor will quickly reach its carrying capacity include: a high silt / clay fraction (>90%) or significant change in % volatile solids (> 90%) indicating a highly depositional (poor flushing) condition; highly negative REDOX readings or shallow discontinuity layer which means that little oxygen is left in the sediment; or a lack of macrofauna (fish or invertebrates) because of low oxygen levels in the near-bottom waters."

From "Bay of Fundy Salmon Aquaculture Environmental Management Project 1997 Final Report", prepared by Eric Garnier, B. Sc. for the New Brunswick Salmon Growers Association.

NB Environmental Management Guidelines (March 2001)

"...Fisheries and Oceans Canada has determined that for purposes of the culture of Atlantic salmon in marine cages, all marine cage aquaculture sites should operate such that oxic conditions are achieved or maintained. Unacceptable habitat concerns occur when the sediment becomes anoxic. Anoxic conditions caused by an aquaculture operation are in contravention of the Fisheries Act. *This is defined by the absence of macrofauna, the change from an aerobic to an anaerobic microflora, or by measurements of sulphide in excess of 6000uM and an oxidation-reduction (redox) potential of -100mV. Hypoxic conditions would be of concern to DFO and would require remediation measures to prevent further progression to anoxia. These conditions are further described...in the table below:" (pp. 10-11)*

Sediment Condition
Observed and measured conditions

Oxic 1

- *Redox potential (Eh)* • *> + 100 mV $_{NHE}$*
- *Sulphide* • *< 300 uM*

Oxic 2

- *Redox potential (Eh)* • *0 to + 100 mV $_{NHE}$*
- *Sulphide* • *300 to 1300 uM*

Hypoxic

- *Redox potential (Eh)* • *0 to -100 mV $_{NHE}$*
- *Sulphide* • *1300 to 6000 uM*

Anoxic

- *Redox potential (Eh)* • *< - 100 mV NHE*
- *Sulphide* • *> 6000 uM*

- *Oxic 1 conditions are related to low effect;*
- *Oxic 2 conditions are related to moderate effects;*
- *Hypoxic conditions are related to a higher level of effect;*
- *Anoxic conditions are related to high level effect.*

the use of the sea floor solely to oxygen tolerant species such a worms."[90]

The 1993 report ended the involvement of NBDOE in aquaculture monitoring for the time being. Funding for the program was not renewed. No monitoring was done in 1994. In 1995, under a new Environmental Management Program (EMP), licensees were required to submit annual environmental monitoring reports to the Minister of Fisheries and Aquaculture on the condition of the bottom under their cage sites. However, since no minimum standards were required as a licensing condition, the reports were simply received as information and no compliance or enforcement action was triggered. This was the case until 2002 when the provincial environment department finally assumed responsibility for regulating the industry.

During this period (1995-2001) requests under the provincial *Right to Information Act* for monitoring results from individual salmon farms were refused under provisions of the Act that protect information not owned by government (the monitoring was paid for by industry)[91] and under confidentiality provisions of the *Aquaculture Act*. Nevertheless, summary reports of environmental monitoring results were acquired for 1997 and 1998.

In 1997, 72 sites were sampled. Of these, 14 sites (19 percent) were rated as having a high level of impact (known as "C" sites); 38 sites (53 percent) had a moderate level of impact ("B" sites) and 20 sites (28 percent) had a low impact rating ("A" sites). The report notes that there was a great variance in conditions under "B" sites, ranging from borderline "A" sites to borderline "C" sites.[92]

In 1998, 88 sites were surveyed and rated according to environmental impact on the sea floor. Ten sites (11 percent) received a "C" high impact rating; 46 sites (52 percent) received a "B" rating; 32 (36 percent) sites received an "A" rating. As in 1997, the "B" sites ranged from borderline "A" conditions to borderline "C" conditions. Seventeen sites (19 percent) were fallow for six months prior to the 1998 monitoring, having eradicated the stock for disease (ISA) control. These inactive sites accounted for some of the improved monitoring results over 1997. In spring of 1999, 9 of the 10 high impact sites were sampled again. Three of these were upgraded to a "B" rating; one of the three had ceased operation in November 1998 and thus had been fallow for several months prior to the spring monitoring. Several new sites, meant to be temporary, were opened in 1998 as part of the ISA control measures and therefore increased the number of "A" rated sites. However, the report noted that many of these new sites were in depositional areas and "may have difficulty maintaining low levels of organic accumulation on the seafloor beneath the cages." [93]

The Environmental Management Program (EMP) changed dramatically with the 2000 announcement that the industry would be subject to the requirements of the *Clean Environment Act* administered by the New Brunswick Department of Environment and Local Government (DELG). The new EMP required two measurements of sediment chemistry B reduction-oxidation potential (Redox) and sulphide gas. These measurements were associated with new site classifications, changing from A, B and C-rated sites to four categories, Oxic 1, Oxic 2, Hypoxic and Anoxic.

While the imposition of environmental guidelines on the industry was a welcome step, official interpretation of the guidelines still allowed for very poor conditions to be maintained under a site. The *Fisheries Act* prohibits any "harmful alteration, disruption or destruction" of fish habitat," otherwise referred to as a HADD. Accordingly, the EMP stated that oxic conditions are the standard for all sites to achieve or maintain. Yet the HADD threshold where enforcement action could be taken was set at anoxic levels, essentially a dead zone. While hypoxic conditions are clearly associated with a degraded bottom environment, remediation plans for hypoxic sites required only that the site not deteriorate further to anoxic conditions. Hypoxic sites were in violation of the approval only if the company failed to implement a remediation plan, not for degrading the environment.[94]

Table 2: Environmental Management Guidelines 2006

Oxic A	– between 100 and 500 µM S	– <30% biodiversity loss
Oxic B	– up to 1500 µM S	– 40 to 60% biodiversity loss
Hypoxic A	– 1500 to 3000 µM S	– 60 to 70% biodiversity loss
Hypoxic B	– 3000 to 6000 µM S	– 70 to 90% biodiversity loss
Anoxic	– >6000 µM S	- >90% biodiversity loss

Although legally mandated under the *Clean Water Act* and *Clean Environment Act* to regulate operations that would pollute the waters of the Province, NBDELG imposed no additional requirements to meet specific provincial mandates. Fisheries Act requirements alone are not sufficient to meet provincial water quality goals.[95]

In 2002, 92 sites submitted monitoring data. Twenty-eight were rated hypoxic and one anoxic; thus, 29 sites (32 percent) were required to develop remediation plans. The anoxic site did not operate after 2002 and subsequent monitoring results for that inactive site improved to hypoxic (2003) and oxic 2 (2004). In 2003, 95 sites monitored; 33 were hypoxic and two anoxic. Thirty-five sites (37 percent) were thus required to develop remediation plans. In 2004, 92 sites were monitored. Twenty (22 percent) of the 92 sites were rated hypoxic; no sites were considered anoxic. One 2003 anoxic site, one hypoxic site and one oxic 1 site were not monitored.

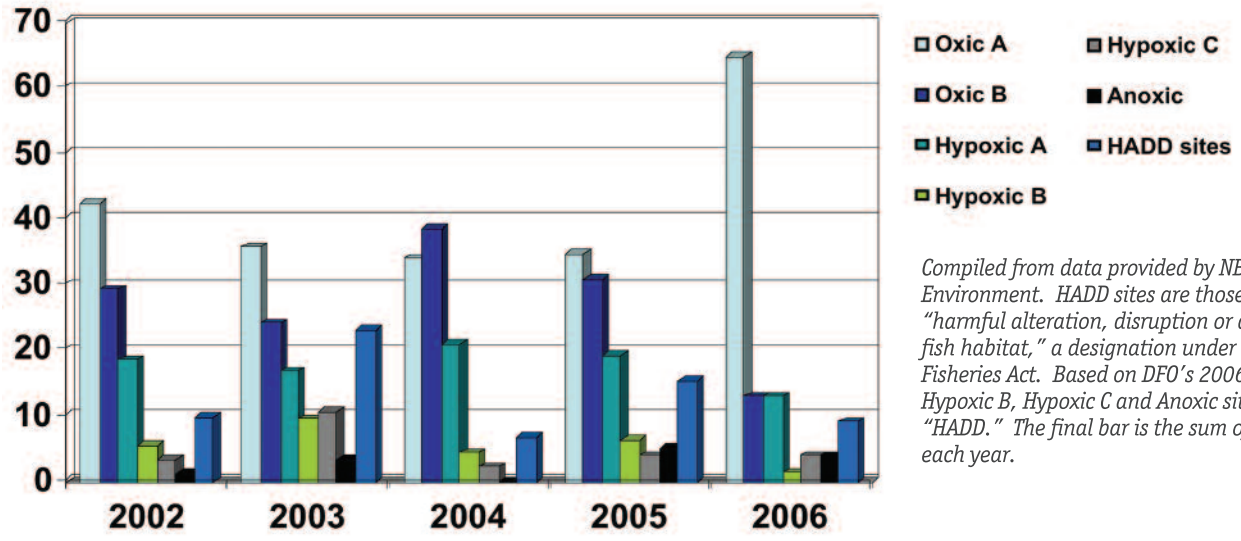
It is worth noting that DELG was rather generous in its interpretation of the monitoring data. The two parameters measured for each site – redox and sulphides – can fall into different classifications. For example, a redox reading may be in the Oxic 2 category while the sulphide reading is in the Hypoxic category, or vice versa. In such a case, DELG rates the site according to the best measurement. This means that the number of higher impacted sites could be greater than the official classification would indicate. To illustrate, in 2003, one site had a redox reading of -98 mV_{NHE}, only two points under the - 100 level at which the hypoxic category changes to anoxic. The sulphide reading for that site was 6812 µM, well over the 6000 µM level at which a site is considered anoxic. The site was obviously anoxic, yet DELG rated the site hypoxic based on the redox reading. As a result, the site owner was not considered in violation of the site approval and the remediation plan needed only to ensure the site not become anoxic, which it already was!

Despite environmental standards being pegged to federal fish habitat requirements, until 2006, the provincial environment department was solely responsible for issuing and enforcing approvals to operate. Environmental enforcement consisted of requiring annual monitoring reports from each site, and random compliance audits done by two new provincial field staff hired to implement the program.

This classification system changed in 2006 when DFO finally assumed responsibility for enforcement of *Fisheries Act* requirements. Under pressure to establish a scientific basis for the HADD threshold used in the New Brunswick EMP, in January 2006 DFO management directed the Science Branch to prepare an "expert opinion" on the relationship between free sulphide concentrations in marine sediments and the effect on animal biodiversity in those sediments (infauna). Prepared by Dr. Barry Hargrave, the report demonstrated that at 3000 µm sulphide concentration between 70 percent and 90 percent of infauna biodiversity was lost. This level, he determined, constitutes a harmful alteration, degradation or destruction of fish habitat, not the 6000 µm threshold.[96]

Accordingly, fish farms with sulphide readings of 3000 µM or greater should require a HADD authorization under subsection 35(2) of the *Fisheries Act*. An authorization is a

Figure 12. Summary of Monitoring Results According to 2006 Classifications *(as a percentage of total sites reporting)*



Compiled from data provided by NB Dept. of Environment. HADD sites are those that cause a "harmful alteration, disruption or destruction of fish habitat," a designation under the federal Fisheries Act. Based on DFO's 2006 classification, Hypoxic B, Hypoxic C and Anoxic sites all result in a "HADD." The final bar is the sum of these sites each year.

permit which would place conditions on the operation of the farm, including the possibility of requiring the company to compensate for the habitat loss by restoring fish habitat elsewhere. Further, any site operating with benthic sulphide concentrations in excess of 4500 µM may be subject to "enforcement action." [97]

Once DFO decided to enforce the *Fisheries Act* based on these thresholds, NBDOE issued a new EMP reflecting these new site classifications. An unacceptable impact was set at 3000 µM S, the point at which 70% loss of biodiversity would occur. The EMP states,

Government regulators recognize the Oxic site classification as the MEQO [marine environmental quality objective] for marine finfish cage aquaculture sites. However, should Oxic conditions not be met, sites must be in compliance with regulatory processes that identify efforts to be undertaken to improve or maintain site conditions.

Fish habitat concerns increase when sediments become hypoxic. Hypoxic conditions are of concern to government regulators and require appropriate site management responses and/or potentially a DFO Fisheries Act *Authorization to prevent further progression to anoxia. Sites with anoxic conditions, and in some cases hypoxic conditions, operating without a* Fisheries Act *Authorization are likely in contravention of the Fisheries Act. These conditions can be defined along a gradient of decreasing presence and diversity of macrofauna and the change from aerobic to an anaerobic flora or by measurements of sulphide in excess of 3000 µM.* [98]

The new EMP, while more stringent, still reflects a concession to industry. A Hypoxic C classification (4500 to 6000 µM S) was added, even though there is no mention of a threshold effect in biodiversity loss at this level in DFO's science expert opinion document on which the new classifications are based. At this level, more stringent management requirements are imposed, and the necessity of a federal HADD authorization is apparently triggered.

Hypoxic B sites may or may not require a HADD authorization, depending on the discretion of DFO habitat managers. Within 30 days of notice that a site is classified as Hypoxic B (3000 to 4500 µM S), the site operator must submit a written report describing the actions that will be taken to reduce organic loading (the deposition of faeces and waste feed) under the site. These are to include modifying the harvest schedule to reduce the number of fish on the most degraded areas of the site, reviewing site set-up and net orientation to take best advantage of current flow, and avoiding any on-site cleaning of nets. The site operator is also required to inform DFO if the site condition is likely to get worse before the end of the production cycle (at which time it would be harvested and fallowed) and "to discuss the necessity for applying" for a HADD authorization under the *Fisheries Act*.

Hypoxic C sites "are causing adverse conditions in the marine sediments directly under the net pens as a result of releases of organic material and have been defined by DFO as unacceptable unless Authorized pursuant to the *Fisheries Act*." These sites must implement additional monitoring, submit a remediation plan for approval, and submit a production plan that does not include any increases and a rationale for maintaining production at existing levels if decreases are not planned. If organic loading is not reduced through modified site operation, the Dept. of Environment (DENV) may order the operator to reduce the size or loading density through a stepped-up harvesting schedule.

An anoxic site "is causing severe damage to the marine habitat as a result of releases of excessive organic material." These are "in non-compliance with DENV Approvals to Operate and site operators will be subject to DENV Compliance and Enforcement Policy." In addition, anoxic sites are like to require a *Fisheries Act* Authorization. "A remediation plan is required within 30 days of notice of site classification." The government may also direct action to be taken on anoxic sites. These could include expedited harvesting, longer fallowing before restocking, increasing monitoring and limitations on production levels, site lay-outs, and equipment requirements.

While remediation plans were required for hypoxic and anoxic sites under the 2001 Environmental Management Plan, there was no deadline specified by which time improvements in site condition would have to be realized. The 2006 plan requires that remediation plans include actions "intended to improve site condition results by the time the next monitoring program is conducted in the following year." It is not clear what measures would be taken if improvements were not achieved, other than to simply repeat the process.

An operator with a Hypoxic C or Anoxic site (and possibly a Hypoxic B site), could be charged with a *Fisheries Act* violation if they fail to apply for and receive a HADD Authorization. Charges could also be laid if an anoxic site operator fails to comply with the requirements of the EMP with respect to such classification. The Dept of

Environment could also revoke an Approval to Operate if the EMP were not followed for hypoxic and anoxic sites.

The other substantial change in the regulation of aquaculture sites in 2006 was the removal of the allowable production limits (APL) and stocking densities (maximum 18 kg per sq m) as conditions in the licence issued by NBDFA. In the face of widespread violation of APLs the industry began lobbying for performance-based rather than prescriptive standards. This approach allows fish farms to determine their own stocking densities and production limits as long as they meet the environmental standards contained in the EMP.

DFO's imposition of a science-based HADD threshold standard on the industry significantly improved the environmental regulatory framework on the industry. However, DFO scientists who had been studying the effects of aquaculture on the marine ecosystem continued to identify shortcomings in that framework. Research had demonstrated cumulative impacts of fish farms beyond the individual sites, particularly in certain poorly-flushed bays containing several fish farms, due in large part to the fact that as much as 90 percent of the solid waste material produced at a farm site is carried off-site by currents. This means environmental monitoring restricted to the farm site itself is only measuring the direct impact of as little as 10 percent of the solid waste discharged from any given site. No monitoring is done of contaminants that dissolve in the water column. Scientists who had done the most extensive research in this area recommended that, in addition to sulphides, monitoring include indicators that can be measured at the farm site but which reflect regional environmental health. The industry takes the position that they cannot be responsible for managing the ecosystem.[99] As of 2007, no area-wide impacts are monitored.

Using the new classification, the percentage of fish farms seriously degrading the marine environment ranged from a high of 23.2 percent in 2003 to a low of 6.6 percent in 2004. Between 2003 and 2006, 18 sites were taken out of commission. Many of these sites were poor performers environmentally. This quite dramatically increased the ratio of oxic sites to hypoxic sites.

The monitoring data over five years reveal some trends. They indicate those areas that are poor candidates for fish farming and/or are stocked beyond their capacity to absorb the wastes discharged from the sites. These include Passamaquoddy Bay, Lime Kiln Bay and Bliss Harbour, Beaver Harbour, Head Harbour, parts of eastern Deer Island and the northern part of Grand Manan. Areas that largely remain in oxic condition are parts of eastern Deer Island, a few sites on Campobello, the southern end of Grand Manan, and the more sparsely farmed area east of Beaver Harbour.

Data also show that site conditions fluctuate according to the year class of fish on the site. The sites are at their worst in the second grow-out year when the salmon are harvested. At four- to five-kilograms they eat more and produce more waste. Once harvested, the site would normally fallow from a few to several months before the site is re-stocked with smolts. In that first grow-out year, the smaller fish produce a smaller footprint, sometimes allowing the site conditions to improve. This is not a universal phenomenon, since some sites are generally bad or generally good. However, there are bay management areas where the fluctuations from year to year appear to be related to the year class on site.

Such fluctuation of site conditions raises the question of whether sustaining high benthic impacts every other year meets the *Fisheries Act* requirement to protect benthic habitat. Just because the sediment chemistry improves during fallowing, does the sea floor regain its ability to support marine life? A three-year research project by the Conservation Council sheds some light on that question.

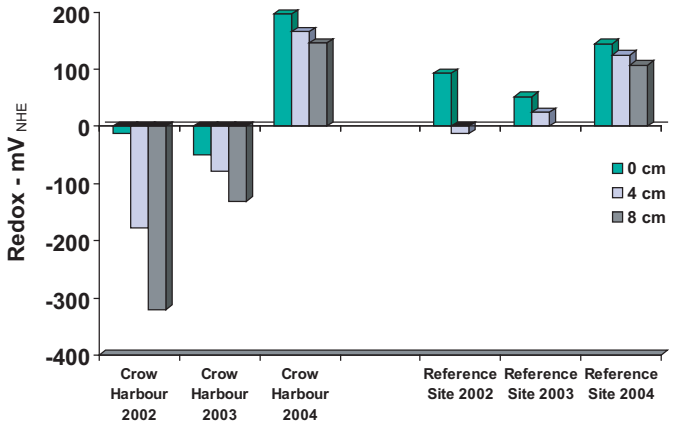
Case Study: Penn Island Aquaculture Site in Crow Harbour

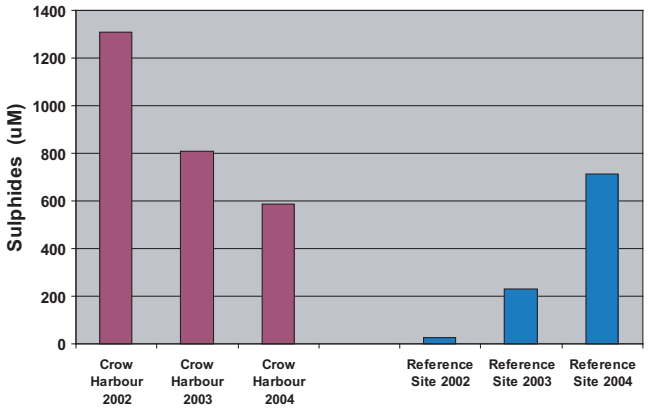
In 2000, an aquaculture company was given a two-year temporary licence for a fish farm in Crow Harbour east of Seeley's Cove. In July, 295,000 smolts were put into 21 pens on a 19 ha lease called Penn Island. Harvesting began 22 months later in April 2002 and finished in early August. The final feeding took place in early July of that year and the site was decommissioned.[100]

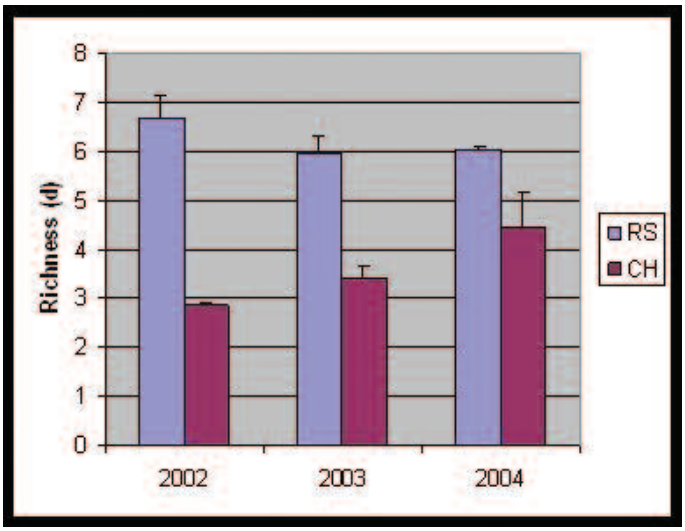
CCNB Science advisor Inka Milewski collects animals living in the sediments as part of CCNB's 3 year monitoring program on the abandoned Penn Island salmon farm in Crow Harbour. Credit: CCNB.

The Conservation Council began its benthic monitoring program on this site on August 24, 2002, approximately five months after the most intensive feeding period and three weeks after final harvest. Sampling was repeated for two more years, on August 27, 2003 and August 23, 2004. The sampling followed the same protocols as those required by government - redox and sulphide measurements along

Figure 13. Crow Harbour Sampling Results







Species diversity results

RS- Reference Site CH- Crow Harbour

transects, and underwater video. CCNB also sampled benthic macrofauna to determine whether degradation and recovery of sediment chemistry was matched by loss or recovery of animals living in the sediments. In addition, CCNB added a reference site some 500-600 m west of the study site. Neither the macrofauna survey nor the reference site is required by government in the industry monitoring program.

In Year 1, three weeks after final harvest, redox measurements at the study site were classified as hypoxic at the surface and anoxic at onlyfour cm depth. After one year, redox measurements were hypoxic at four cms but still anoxic at eight cms depth. Sulphides were in the Oxic 2 range. After two years, redox had recovered to the Oxic 1 range to a dept of eight cm and sulphides had dropped to the Oxic 1 range. In all three years, redox and sulphides at the reference site were in either the Oxic 1 or Oxic 2 categories. Clearly, the change in conditions at the study site was related to the fish farm.

Recovery of marine organisms at the study site was not as satisfactory. After two years of fallowing, although some recovery occurred, the diversity and numbers of species at the study site remained lower than that of the reference site. This suggests that species recovery lags behind improvements in sediment chemistry.

Important lessons were learned from the Penn Island site monitoring. First, site location is very important. This site was poor because hypoxic conditions were created after just two years in operation. Second, it took a year, not just a few fallow months, to realize an appreciable improvement in sediment chemistry. Third, there is a significant lag time between improvement in sediment chemistry and the re-colonization of the impacted area by benthic animals. Thus establishing fallowing periods simply on the basis of chemistry improvements probably prevents the recovery of the site's ability to support benthic infauna. This points to the need to add benthic macrofauna sampling to the environmental monitoring protocols, for fallowing periods to be extended to the point where some threshold of animal recovery is achieved, and for a monitoring reference site to be established for comparison purposes.

Carrying capacity of southwestern Bay of Fundy

The escalation of disease occurrences and environmental degradation brought repeated claims that there were too many fish being grown in southwestern New Brunswick and that the government must determine the capacity of each bay to support fish and assimilate wastes. Besides the Conservation Council, one notable voice on this issue was the Premier's Round Table on Environment and Economy. After an investigation by its Aquaculture Working Group,

the multi-sectoral Round Table recommended in 1998 that a moratorium be imposed on further increases in biomass production and that in certain areas production be scaled back. This would be in place "until the assimilative capacity has been determined, the industry has experienced a stable period, and a management structure has been developed to ensure that the industry remains within the ecological limits of the area in which it is located."[108] They were not alone. The Conservation Council and fishermen's organizations were also pushing the government to do the necessary research to provide some scientific basis for determining a level of fish production that would not degrade the coastal environment.

More than 20 years after the industry started in this region, DFO began to support some ecosystem-level research to guide aquaculture management and growth. A project called "Environmental Studies for Sustainable Aquaculture" (ESSA) was initiated in 2000 and concluded in 2003 with a total budget of $728,000 (small compared to dollars poured into industry-driven research). Its purpose was to develop methods and tools to determine the capacity of coastal bays to absorb aquaculture wastes (assimilative capacity) and to assess the far-field effects of aquaculture (beyond the immediate vicinity of a salmon site). These studies were to assist DFO habitat managers in ensuring that aquaculture development does not harm fish habitat.

Several reports were produced, including a review of environmental effects of finfish aquaculture, particularly in relation to ecosystem-level or far-field effects.[109] It concluded that while most of the evidence of effects is within the vicinity of fish farms (near-field effects), measurable effects of finfish aquaculture have been observed at a broader scale. These relate to eutrophication, sedimentation, and changes in food web structure and

CASE STUDY: *Aquaculture in the L'Etang Inlet*

The L'Etang Inlet, sometimes called L'Etang Estuary, is a fiord-like estuary located just east of Passamaquoddy Bay. It is approximately 15 kms in length with a watershed area 86 km^2 and has the highest concentration of salmon farms of all salmon growing areas of the world. Most of these sites are located in two areas of the inlet, Lime Kiln Bay and Bliss Harbour, each encompassing an area of 3-4 km^2. Another salmon farming area, Back Bay, is also within the inlet.

Monitoring of environmental conditions in the inlet began in the 1970s when problems arose from a pulp mill built on a tributary flowing into the upper reaches of the inlet. The upper L'Etang became heavily polluted with organic enrichment due to excessive sedimentation and contaminant discharges from the mill. In 1975, five years before salmon aquaculture was established in the lower L'Etang, benthic monitoring found that the effects of organic enrichment declined progressively with increasing distance from the upper L'Etang. Lime Kiln Bay in the lower L'Etang was the least impacted. The absence of the effects of organic enrichment in this area indicates that it was not impacted by fish processing plants in adjacent Black's Harbour and Back Bay.

Conditions improved in the upper L'Etang after pollution controls were installed on the pulp mill in 1988. Species diversity in the sediments increased, and the sludge worm *Capitella capitata* which thrives in oxygen-deprived sediments was dramatically reduced in number.

Meanwhile, salmon aquaculture was established in the outer L'Etang in 1980; by 1992, 22 salmon farms operating there. Collectively they were the single largest contributor of nitrogen and phosphorus into the estuary. Discharges from the largest salmon farm in the estuary included 120 MT of carbon, 41 MT of nitrogen and 6.4 MT of phosphorus.[103] DFO researchers warned that that the government's stated goal to double aquaculture capacity in the estuary was ill-advised.[104] Their caution was ignored. By 1997, the number of aquaculture sites in the L'Etang Inlet had almost doubled to 41 sites.

By 2000, benthic monitoring in Lime Kiln Bay where the greatest concentration of sites was located, revealed extensive changes in the animals inhabiting the sediments since 1975. At the beginning of the enrichment/ eutrophication process, there was an increase in species richness, accompanied by a shift in community structure towards critters that feed on bottom sediment. Then the system crashed. By 1997, the dominant species in 1975 had disappeared from the lower inlet, a trend that extended inward to the centre of the inlet. This effect continued even though Lime Kiln Bay was emptied of fish for about a year and the number of sites reduced to control a serious disease outbreak.[105] Concentrations of oxygen-depleting organic matter in Lime Kiln Bay and Bliss Harbour dropped but the benthic community structure did not recover.

function. It also identified the occurrence of antibiotic resistant bacteria related to the use of medicated feed on salmon farms as a potentially serious far-field effect.

These studies [110] [111] found that in some areas dissolved nutrients, faeces and uneaten feed released from salmon farms were found in the water column and sediments over 500 m away, and that sediment deposition in the L'Etang Inlet is dominated by local aquaculture sites. A model was developed to assess optimum holding capacity of fish in a particular coastal management region (CMR).[112] Optimum holding capacity is the number of fish held within an area that would maintain oxygen, nitrogen and carbon levels within the natural ranges of variability.[113] Calculations showed that the 2002 licensed salmon production capacity in the L'Etang Inlet (Lime Kiln Bay, Bliss Harbour, Back Bay) would have to be reduced by 90 percent to meet the <20% threshold of total fluxes in this CMR. The report states, "If APLs [allowable production limits] remain at current levels, it seems almost certain that increased eutrophication will lead to higher nutrient levels with more frequent and widespread oxygen depletion and organic enrichment. There will also be increased likelihood of disease and parasitic infections."[114] The model indicates that salmon grown in the other CMRs as delineated by this study do not exceed the 20% threshold.

One of the more localized impacts that would not necessarily get picked up as a significant effect in a larger management area is oxygen depletion in the vicinity of fish farms due to salmon over-stocking. Oxygen depletion has resulted in fish losses for the industry with unknown ecosystem and wild species impacts. Below a threshold level of 6 mg dissolved oxygen (DO) per litre of water, fish health is known to deteriorate. Below 6.75 mg DO per litre, salmon behaviour changes. Ambient DO levels offshore in the Bay of Fundy range from 7 to 9 mg per litre. If salmon respiration requires a long time to use up the DO buffer relative to the time needed to flush and re-oxygenate the bay (ratio > 1), then the risk of using up the buffer is small. If DO is being used up faster than the flushing time can replace it (ratio < 1), then salmon in farms are likely to deplete the buffer and the DO levels would drop below the 6 mg per litre threshold.

This calculation was only done for Seal Cove Sound, Grand Manan. There were five salmon farms operating in winter 2003-04 with a combined estimated site potential (ESP) of 1,744,000 fish. The allowable production limit (APL), a percentage of the ESP, was 1,269,000 fish. A flushing time of 6.6 days was used (95% of water exchanged). Because background DO levels were not precisely known, two calculations were made. Using the 9 mg/l background level (buffer of 3 mg per litre), the resulting ratio is greater than one and suggests there would be some room to increase production towards the ESP. Using a more prudent assumption of 7 mg/l DO background results in a <1 ratio, indicating the ESP for Seal Cove Sound is too high and there is little room to increase salmon production levels.[115]

The intertidal zone is a specific area where the effects of nutrient loading may be observed. Researchers examined several inlets in southwestern New Brunswick away from direct discharges of nutrients such as sewage treatment plants or industrial waste effluents. They found levels of dissolved nitrogen higher than those offshore, indicating the cumulative effect of local sources of nitrogen. They also found increased coverage of intertidal flats by the bright green nuisance algae, *Enteromorpha* sp. and *Ulva* sp., an indicator of excess nutrients in the water.[116]

In one Deer Island cove, the surface area covered by algae had increased from 2% in 1984 to 32-48% between 1999 and 2001. Since other factors were constant, it is reasonable to attribute the increased nutrient load to increased aquaculture in the area. Clams in the intertidal flats responded negatively to the algal mats. In general, the density of clams was lower under the mats than in unaffected areas. Under older algal mats, sediments were anoxic (devoid of oxygen) and some clams were lying on the surface rather than buried. Clams of all sizes and in all months sampled were at much shallower depths than those not covered by algal mats. A lab experiment saw clams immediately surface when covered with algae while control clams remained buried. When the algal mat was removed, the clams reburied. This changed behaviour in response to the algal mats could increase predation. Clams covered by algal mats also exhibited decreased growth and gonad production which could mean either reduced reproduction success or an altered spawning season.

The researchers concluded that there is a biological effect on soft-shell clams of these green algal mats caused by eutrophication, and that salmon farming operations were likely responsible for at least some of the algal build-up in some areas. This has a direct and significant economic impact on the clam harvesting industry. [117]

While algal blooms are clearly associated with nitrogen loading from salmon farms, the study did not establish a direct effect between proximity to salmon farms and increases in phytoplankton blooms.[118] This may be because phytoplankton production is controlled by light penetration. In the Bay of Fundy, such penetration is low and therefore plankton production cannot handle the entire nutrient load. Instead, excess nutrients are drawn down by bacteria in what is described as a phytoplankton - nutrient- detritus - bacteria ecosystem. This creates a

sustained "biological oxygen demand" that continues until the nutrient supply is used up, which in turn results in low dissolved oxygen in the water column.[119]

Although total production of phytoplankton does not seem to have increased as a result of nutrient loading from aquaculture, there has been an increase in the occurrence and volume of less edible (to marine species) and toxic species of phytoplankton. Such change in plankton community structure can be triggered by a change in the ratio of nitrogen and phosphorus in the marine environment which occurs with an excess loading of nitrogen. The consequences of such changes throughout the food chain are poorly studied.[120]

Disease & Chemicals in Bay of Fundy Aquaculture

A number of chemicals are employed in salmon farming operations. Those chemicals include sea lice treatments, antibiotics to treat certain diseases, anti-foulants such as copper used on nets and other equipment, other metals (cadmium, lead, copper and zinc) which leach from cage structures or are found in fish feed (copper, zinc, manganese, iron), other feed contaminants (e.g. PCBs, dioxins, furans, PAHs), disinfectants used to control disease organisms (chlorine, hypochlorite and others), polystyrene and plastics, and so-called "inert" and unknown substances in chemical formulations. These contaminants end up in marine waters and sediments, yet scientists admit they do not know what affect they have on the long term health of the coastal environment.

Very little research has been carried out on chemical contaminants from aquaculture in southwestern New Brunswick. However, scientists suggest that the highest environmental risk comes from the accumulation of metals in sediments and the potential of parasiticides, a type of pesticide used to kill external parasites known as sea lice, and drugs to affect other marine organisms.[121]

According to Dr. Larry Hammell, a fish veterinarian at the Atlantic Veterinary College, growing fish together in high densities often stresses the fish, making them more vulnerable to disease. As a result wild fish that carry disease without being affected can transfer disease vectors to fish farms with devastating effects.[122] Pollution and nutrification (excess nutrient loading) due to the release of surplus food and faeces, pesticides, antibiotics, anti-fouling agents and other materials from aquaculture sites also increase stress on farmed fish, impairing their growth and lowering their physical capacity to resist disease. Chronic disease, slow growth and increasing mortalities (fish deaths) are overt indicators of the degree of stress to which fish are subject.[123]

That stress has been evident in Bay of Fundy farmed salmon almost since the industry began. According to the New Brunswick government, the annual mortality rate for farmed salmon grew from less than five percent in the mid-1980s to an average of 20 percent by 1997.[124] That means on average 20 percent of the salmon across all the farms were dying prematurely, an increase of 300 percent over ten years.

Diseases occurred even before the massive expansions of the late 1980s. An outbreak of furunculosis, a bacterial disease, was first reported in 1984 in four hatcheries and two sea cage sites. In 1985, it showed up in four hatcheries and five cage sites.[125] This cut into salmon profits and temporarily created a shortage of smolts. Furunculosis is one of the most serious diseases of farmed salmon, partly because the bacterium causing the disease quickly develops resistance to antibiotics. The bacterium is present in wild and farmed salmon populations, but it does not multiply or survive for any length of time off the fish host unless there is a high organic load in the water.[126] Since organic material in the form of uneaten feed and faeces are constantly present in sea cages, and the furunculosis-causing bacteria are known to persist in "carrier-fish", the threat of furunculosis outbreak has become constant. Outbreaks occurred again in 1989, 1990, 1993, and 1994. By 1989, the New Brunswick government had begun to develop a program to identify and restrict the movement of furunculosis carrier-fish between licensed aquaculture facilities.

The most vivid demonstration of how aquaculture wastes promote fish disease occurred in the mid-1980's in Dark Harbour Pond, Grand Manan, a relatively large salt water pond behind a barrier beach with only a narrow channel to provide tidal flushing. Because of the shelter provided, it was initially seen as an ideal sea cage site. However, aquaculture sludge accumulated quickly beneath the site, and after only a few years of operation salmon developed bacterial kidney disease (BKD) and serious parasite infestations, the first outbreak of sea lice in the Bay of Fundy. Moreover, the salt water pond as a living ecosystem was essentially killed. The site had to be completely abandoned for several years while the pond flushed itself out. Today a smaller salmon operation is located there; environmental monitoring results show it to be hypoxic with sulphide readings in 2004 and 2005 at or near Hypoxic B levels. While Dark Harbour is exceptional because of its low flushing rate, the experience there underlined dramatically how the assimilative capacities of marine ecosystems are limited.

In 1989, New Brunswick reported its first case of Hitra caused by the bacterium *Vibrio salmonicida*. Over the next two years, only two other cases were reported, but in 1993 a major outbreak occurred with nearly half of all cage sites infected. Hitra was first reported in Norway's salmon farms in 1977, and huge losses occurred there in 1979. The Norwegians had identified a number of contributing factors, such as high stocking densities and poor water quality. Despite vaccinations and better management, they had not been able to prevent Hitra outbreaks. By 1993, Norway had moved to a system of fallowing sites for six to eight months and legislating lower stocking densities, daily removal of morts (dead fish), and disinfection of all blood and morts in an attempt to control the disease.[127]

The New Brunswick response, when faced with the disease, was simply to recommend vaccination of smolts.[128] Even then, coverage was spotty. Hatcheries used a water base or immersion process whereby the vaccine is absorbed by the gills and skin. This is fast, economical and efficient; however, potency is not high and probably has no effect after a year.[129]

As in terrestrial livestock operations, treatment of bacterial diseases such as furunculosis, Hitra and bacterial kidney disease, includes administering antibiotics. They can be administered as a feed additive, by injection, or by antibiotic baths. Injection results in lower antibiotic use and reduced environmental impacts, but it is the most expensive. Medicated feed is less effective because sick fish do not feed well, and the gut does not absorb the drug efficiently. Therefore, uneaten medicated feed builds up the sea floor, and a relatively high percentage of the drug is excreted in faeces. Baths are easier than injections and more effective than feeds but it also means that antibiotic-contaminated water is usually released directly into environment.[130]

The quantity of antibiotics used during the early years of the industry to prevent and control disease outbreaks was very large (one government official called it 'impressive'). Usage averaged 400 grams/tonne of fish produced by the late 1980's. By the early 1990's usage was down to 200 grams/tonne (compared to Norway's 165 grams/tonne).[131] A study of antibiotic use in Atlantic Canada in 1998-99 estimated that 230 g of the antibiotic oxytetracycline (OTC) was used per tonne of fish produced, or 42 g per 1000 fish.[132]

While use of antibiotics to control disease has decreased over the years on a per tonnage basis, those reductions have been offset by increased tonnage of fish produced. Based on 1989 New Brunswick production figures of 3,993 tonnes, 1.6 tonnes of antibiotics were being used annually. Ten years later, based on production of 22,000 tonnes, 5.06 tonnes of antibiotics were used. Production peaked in 2002 at 38,900 tonnes. That year, nearly 9.0 tonnes of antibiotic would have been used, based on the 1998-99 estimate of 230 g/tonne. Even at 200 g/tonne, 7.78 tonnes of OTC would have been used in southwestern New Brunswick that year.

Until 1990, there were no mandatory federal withdrawal periods to ensure the elimination of medication, anti-foulants, or pesticide residues in salmon. This is the time between chemical treatment of fish and when it can be harvested and sold. Some industry associations adopted American standards of 45 days withdrawal time to clear any medication before marketing their product. These standards were not legally enforceable and some farmers used a much shorter (21-day) withdrawal period. In 1990, the federal Department of Fisheries and Oceans Inspection Branch began to monitor and report on drug, pesticide and chemical residues in farmed salmon. Growers were instructed to document any therapeutic treatment they used and confirm that they had complied with prescribed withdrawal times.[133] Any farmed salmon destined for domestic or export markets have to be processed in federally registered facilities, administered since 1997 by the Canadian Food Inspection Agency. These plants are now required to evaluate incoming fish to ensure that drug residue limits are not exceeded.

In 1993, DFO reported that, of 362 lots of salmon and 30 lots of trout examined for antibiotic oxytetracycline, 12 lots exceeded the action alert level of 0.1 parts per million (ppm).[134] By 1996 there were virtually no samples of salmon tested by DFO with detectable levels of antibiotic residues.[135]

A greater concern today is the development of antibiotic resistant bacteria from the build up of medicated fish feed in sediments. As early as 1990, a strain of furunculosis (*Aeromonas salmonicida*) isolated in a New Brunswick cage site was shown to be resistant to OTC, the usual treatment for *Vibrio* diseases.[136] Studies in salmon farming areas also suggest that sediments under fish farms may be reservoirs for antibiotic resistant bacteria. In the West Isles region of the Bay of Fundy, researchers sampled sediments around 11 salmon farms in different inlets for the presence of such bacteria. They found bacteria resistant to oxytetracycline (OTC), the most common antibiotic used in Canadian aquaculture, in all sediment samples collected up to 100 m from the centre of the cage sites. They concluded that antibiotic resistant bacteria occur over a broad area where there is intensive salmon aquaculture, and that the source may be medicated feed pellets.[137] Some antibiotics,

especially OTC, persist for long periods in marine sediments. Lab and field experiments with oysters and crabs show this drug accumulates in tissues, and resistance to the drug has been shown to occur in fish and other marine species near aquaculture sites.[138] Resistant bacteria were not found in control areas where there is no fish farming.[139] As the threat of super bugs that do not respond to antibiotics grows, the use of these products in food production, both aquaculture and terrestrial livestock operations, must come under greater public scrutiny.

Infectious salmon anaemia (ISA)

In the midst of the devastating sea lice infestation in the mid-1990s, New Brunswick salmon farmers were hit hard by an unknown disease that was killing their fish. Although the first dying fish were discovered in summer 1996, provincial officials were not notified of the mystery disease until that autumn. Fish vets dubbed it haemorrhagic kidney syndrome (HKS) after the symptoms the sick fish presented.

After a relatively slow start, by September 1997 HKS had hit 19 or 20 farms out of 83 licensed operations.[140] Outbreaks were initially concentrated in Seal Cove Sound (Grand Manan) and Lime Kiln Bay, and then spread to farms in Bliss Harbour, Deer Island and Back Bay. The hardest hit farms reported mortality losses of 20 to 30 percent.[141] Disease specialists worked for nearly a year to isolate a cause for the disease. Finally, in early September 1998, a virus associated with Infectious Salmon Anaemia (ISA) was isolated in the affected fish.

ISA was first reported in Norway in 1984, although it could have been present on Norwegian fish farms as early as 1977/78. The disease is now considered endemic in that country. Research there showed that sea lice are potential vectors for the spread of ISA.[142] Research also found a direct correlation between heavily infected farms and proximity to salmon processing plants. Blood water released from these plants is a host for the virus which affects the blood of live salmon.[143] Another pathway is the improper disposal of infected fish carcasses. Norway managed to control losses from ISA (although not eliminate them) through a program of slaughtering infected fish, disinfecting farms, restricting fish movement, disinfecting farm and processing offal and waste water, and disease surveillance.

Some of the 15 salmon processing plants located in southwest NB at the time were discharging blood water directly into coastal waters. John Kershaw, NBDFA's Director of Aquaculture at the time of the ISA outbreak, admitted that his department's approach had been to allow the industry to write its own rules of operation. ISA brought a change of heart. He stated, *"If anyone in the past doubted that the effluents from the processing plants were having an effect on the fish…there is no doubt left now….. Obviously now we have to look at tighter controls."*[144] Disposal of dead fish, or morts, had also been a problem. Permits for at-sea dumping of morts are required from Environment Canada. However, there had been numerous reports of illegal dumping of morts into coastal waters. Legal or not, it was a recipe for disease problems on salmon farms.

Despite strong evidence that immediate slaughter of stock from infected farms was necessary to control ISA, NBDFA was slow to respond. A slaughter order would entail massive reductions in stocks with the potential of wiping out several operations, and paying out millions in compensation. Eventually the government did act, unsuccessfully, to eradicate the virus. Between 1997 and 1999, nearly 4.5 million fish were slaughtered on 65 sites (not all these sites were clinically diagnosed but several in proximity to infected cages were eradicated to try to control the spread of the virus).[145] Three bays – Lime Kiln Bay, Bliss Harbour and Seal Cove Sound – were completely emptied of fish and ordered to fallow for six months to try to break the disease cycle. Temporary sites were granted in new areas to keep some companies operating. Fish farmers were ordered to replace wooden cage structures and vessels which could not be readily disinfected. Biosecurity and fish health management protocols were developed to try to eliminate the transfer of infection from site to site and to improve husbandry practices. The new Aquaculture Site Allocation Policy introduced in 2000 introduced single year class management in new Aquaculture Bay Management Areas, a measure specific to ISA control. Discharge of blood water from harvesting and processing operations into coastal water was prohibited, as was the at-sea disposal of morts.

ISA appeared in Scotland in 1998 and Nova Scotia in 1999.[147] The disease first occurred in Maine in 2001 when all 17 farms in Cobscook Bay were either infected or exposed to the disease. One of two farms on the Perry Shore in Passamaquoddy Bay was also infected. Two million salmon were slaughtered and the farms fallowed in an attempt to wipe out the disease, although it has re-occurred as salmon were re-introduced to Cobscook Bay. No new sites were infected in 2002, but two were infected in 2003 and six in 2004.

In New Brunswick, as each year brought continued and spreading infection, industry and regulators began to talk about disease management, not eradication. A vaccine

hurriedly developed did not work. Rather than destroying all salmon on a farm where ISA was present, the approach was changed to emptying only those cages (among many in a single farm) in which infected fish were found. In 2000, nine fish farms were infected and 222,000 fish destroyed. Over the next two years, the numbers increased again to 15 sites with 1.1 million fish destroyed (2001); in 2002 16 sites were infected with a record 2.4 million fish destroyed. Numbers dropped again in 2003, with 10 sites destroying 406,000 fish. In 2004, only one infected site was reported. Numbers of fish destroyed are not known. Numbers went up again the next year. From September 2005 to July 2006, 14 sites were ISA positive and 950,000 salmon were destroyed. That brought the number of salmon culled for ISA control to 9,600,000.[148]

The ISA financial toll has been severe. Several businesses went bankrupt or sold out to larger companies.[149] By the end of 1999, the cost to industry was approximately $50 million, including direct sales losses and decreased business in processing, packaging, feed sales and other related industries.[150] After the first slaughter orders in 1997-98, government paid out $40.5 million ($32 million from Ottawa, $8 million from Fredericton) in compensation and disease management costs. Farmers received $8 per fish killed. Because there were no aquaculture compensation programs (unlike for livestock), funds were scrounged from other programs. The federal contribution, for example, came from the Disaster Financial Assistance Arrangements generally used to cover costs of natural disasters such as ice storms, hurricanes and floods.

After 1999, however, fish kill compensation was not continued. On the urging of government, the industry established the East Coast Aquaculture Industry Compensation Fund, into which the provincial government paid another $1.2 million and the industry was to contribute 10 cents per fish. This was not enough and the fund was never able to provide compensation as the slaughter orders continued each year. From that point, the industry began lobbying for a government-sponsored compensation fund like those for agricultural products.[151]

In Spring 2004, the Atlantic Canada Opportunities Agency (ACOA) announced a loan of $7.5 million to six salmon aquaculture companies to replenish stocks lost to ISA, the money to be paid back in two years when those fish would be harvested.[152] NBSGA spokesperson Nell Halse said the loan was not compensation for fish kill orders. According to Halse, the cost to salmon farmers for fish health measures in 2003 was $13 million. A "more robust" compensation plan was anticipated by Spring 2005.[153]

In January 2005, a federal-provincial-industry task force was struck to "examine ways to contribute to sustainable salmon farming industry in Atlantic Canada." [154] This mandate was more explicitly stated in the April 2005 report of the Task Force: "to review and report on the financial state of the salmon farming industry in Atlantic Canada, identify options and provide recommendations regarding: a) programming requirements to stabilize the industry; b) initiatives to respond to market challenges and c) requirements to enhance a sustainable salmon and alternate finfish species industry." [155]

At the top of the recommendations list was a requirement for emergency funds "within the next several weeks." On a longer term basis, the task force called for an Aquaculture Framework Agreement that would include "financing and business risk management" elements, as well as other supports (p 2). In July of that year, Fisheries and Oceans Canada announced it would provide up to $20 million in one-time emergency funds to assist farmers that have "experienced significant uncompensated losses due to eradication orders aimed at disease control." The money was contingent, however, on a bilateral agreement with New Brunswick that would "outline federal-provincial accountabilities and cost-sharing methods," and agreement on a restructuring plan for the industry that would put it on a sound financial footing, including "consolidation, re-location and fallowing of salmon sites in the Bay of Fundy over the next three years." [156]

The condition of a bilateral agreement with New Brunswick for cost-sharing was not accepted by the provincial government, however. After a year of wrangling and no money going to salmon farmers, in summer 2006 Ottawa finally wrote a cheque for $10 million and closed the file. The new Conservative government in Ottawa did not share the industry's enthusiasm for longer term support through a program similar to those provided to the agricultural sector. How that $10 million was allocated is unclear.

Sea lice

Sea lice are naturally occurring parasites which rarely have a significant effect on wild fish. The crowded, stressed conditions of salmon farms, however, provide a perfect breeding ground for this tenacious parasite. Sea lice attach themselves to the host fish causing skin ulcerations and bleeding. It is possible that constraints on swimming speed within fish pens may increase the probability of lice attachment.[157] While adult fish may not be killed by lice infestations, scarring caused by sea lice greatly diminishes the market value of the fish. Smolts, however, are much more vulnerable and can die when attacked by as few as four or five sea lice.

In 1994, hard on the heels of a major Hitra outbreak,

salmon farms were hit with a major infestation of sea lice, costing the industry $10 million in lost salmon. The next year, the direct and indirect loss of 187,000 market-sized salmon to sea lice resulted in a financial loss of about $24 million to the industry.[158] Salmon prices were already dropping due to market conditions, and prices for fish coming out of sea lice-infested farms were even lower. Growers were desperate. At a conference in September 1995, NBDFA Director of Aquaculture John Kershaw, said, "As of today, we're fighting a losing battle. Farms are going bankrupt. This is the industry's biggest challenge.... We're in survival mode." [159]

At that time, no pesticides or drugs were registered for use in the marine environment. Pesticides are regulated under the federal *Pesticides Control Act* by the Pest Management Regulatory Agency (PMRA) in Health Canada. In order for a pesticide product to be used legally, it must first be registered for that use by the PMRA. In addition, in New Brunswick the *Pest Control Products Act* requires an application permit to be issued by the Department of Environment before a registered pesticide can be applied (no permit would be issued for a non-registered pesticide).

Through intense lobbying, federal emergency registration was granted for hydrogen peroxide and the insecticide pyrethrin. To treat sea lice with pesticides such as these, lice-infected salmon would be drawn up to the water surface in tarpaulins and then bathed in chemical solutions. Once the treatment was completed, the used bathing solution would be dumped into the sea. Repeated applications would be necessary to prevent re-establishment of lice on the fish.

Although expensive, hydrogen peroxide was initially the most common product used by Bay of Fundy fish farmers.[160] As late as April 1995, no environmental review had been conducted in Canada of hydrogen peroxide for use as a pesticide in a marine environment.[161] Monitoring of concentrations of the pesticide was done on New Brunswick salmon farms in 1994. Results indicated that hydrogen peroxide concentrations in water used to treat salmon could exceed 4000 mg/kg at the end of treatment and marine organisms outside the salmon pens would be exposed to a shock of treated water when the tarpaulin would be dropped and water flushed from the pen. There were no data on the dispersion of the chemical in the surrounding water. Based on the results of several studies, the persistence of hydrogen peroxide in seawater is measured in days, not hours. The effects on other marine species of sequential, single-day treatments or numerous adjacent pens multiplied by five, six, or more, treatments per season are unknown.[162]

According to an Agriculture Canada Pesticides Directorate bulletin, the synthetic pesticide pyrethrin is "highly toxic to fish and other cold-blooded animals" and thus should be kept out of water. "Direct application to a body of water will likely result in significant mortality rates to aquatic invertebrates, possibly affecting the growth and survival of higher animals in the food chain." [163] Nevertheless, this product was given an emergency registration for use in the Bay of Fundy in the battle against sea lice.

Cypermethrin, a pesticide chemically related to pyrethrin, did not receive an emergency registration in Canada during this crisis, although it had been used to treat sea lice in Europe and in Maine, and was widely known to have been used illegally in New Brunswick. Cypermethrin has the potential to bioaccumulate in the environment and is very toxic to fish, aquatic insects and crustaceans. Cypermethrin bound to suspended organic matter (i.e. fish feed or faeces) and sediment could expose zooplankton and benthic organisms to the chemical.[164]

In 1995, an anonymous memo, referred to as the "cookbook," began circulating throughout the New Brunswick aquaculture industry instructing salmon growers on the illegal use of Ripcord®, an agricultural chemical containing cypermethrin. Ripcord® is formulated to be used on plants and remains toxic longer than the cypermethrin product used in aquaculture (trade name Excis®).[165] That same year, a local salmon grower was found guilty of illegally using cypermethrin and was fined $500. One investigator working on this case noted that,

[T]here has been extensive unregistered use of cypermethrin by salmon growers. Some farmers indicated that with losses in excess of $10,000 per day they would use unregistered products if they can save their salmon and pay whatever fines were levied if they were caught.... Enforcement would be extremely difficult because the growers can just wait until we are not around and then treat the salmon and residues in the water and fish would be virtually undetectable.[166]

Cypermethrin made the news again in 1996 following a disaster at a local lobster pound. In July, 60,000 lobsters (over 80,000 lbs valued at $700,000) being held in the tidal impoundment before being shipped live to markets, mysteriously died. After traces of cypermethrin were detected in samples of the dead lobsters, four companies which owned the lobsters sued several salmon operations, DFO, and others. The plaintiffs alleged that toxic chemicals used by one or more of the defendant fish farm owners contaminated the aquatic environment including the lobster pound causing mass mortality, sickness, and heavy

financial losses. They also alleged that DFO was ignoring the illegal use of organochlorinated pesticides on salmon farms.[167] The case was settled out of court and no details of the settlement were made public.

On numerous occasions in 1995 and 1996, NBDFA corresponded with the federal Pest Management Regulatory Agency which approves pesticides for legal use in Canada, to request emergency registration for cypermethrin. In a September 1995 letter to the PMRA , the chief provincial veterinarian overseeing the salmon aquaculture industry wrote,

Could we please have an emergency permit to use this now, as the largest food producing sector[168] in the Province of New Brunswick is being destroyed. I am also making an appeal on behalf of humaneness and animal rights... Presently, lice are first eating the skin off the heads of our salmon and then the muscle covering the skull. I have seen numerous cases of fish with their skulls exposed, and still surviving... To not approve an efficacious and economical product to treat our salmon is criminal.[169]

Cypermethrin was never granted an emergency permit.

Provincial politicians and NBDFA were also putting extreme pressure on the PMRA to fast-track the registration process for Salmosan®, with the active ingredient azamethiphos. Salmosan® belongs to the organophosphate group of pesticides (including trichlorfon and dichlorvos widely used to control sea lice in Norway, Scotland and Chile), which work by disrupting the central nervous system of the parasite. Salmosan® was developed to replace the less toxic cousin dichlorvos to which sea lice had acquired some resistance. Research on its effects on species other than salmon demonstrated that such products depress immune systems (carp[170]) and are toxic to shrimp[171] and zooplankton.[172] In its safety data sheet for azamethiphos, Novartis calls it a marine pollutant and states it is "very toxic to fish." It warns, "Do not contaminate watercourses or sewers." The Scottish government has also determined that azamethiphos (and cypermethrin) can stimulate toxic algal blooms which cause shellfish poisoning.[173]

Late in 1995, Salmosan® was registered for aquaculture use in Atlantic Canada only, a direct response to that lobbying.[174] Although new chemical products can take from three to five years to get through the registration process, Salmosan® was pushed through in eight months using environmental data provided by the manufacturer Novartis (formerly Ciba Geigy) based on testing done in Europe. Just two months earlier, a PMRA official had written, "the request for emergency registration for azamethiphos by the Province of New Brunswick cannot be processed because the active ingredient has not been previously registered in Canada [and] there is insufficient time to conduct a review of information to allow for the use of this product for this emergency situation."[175] Despite this, the product was approved with no prior Canadian testing done.

Subsequent testing found that aazamethiphos does not accumulate in an organism but it does induce genetic mutations which could result in delayed rather than immediate effects on exposed animals. Lab tests which directly exposed salmon to the chemical found it to be lethal at levels higher than the recommended dose in solution. However, it was found to be lethal to larval and adult lobsters and shrimp at much lower levels (1 to 3% of the recommended treatment dose), and significantly more lethal in the summer than at other times of year. It was also found to affect behaviour in surviving lobsters and repeated exposures were found to affect female spawning. A field trial in which lobsters were indirectly exposed during actual farm treatments did not reveal effects in the short term.[176]

The Canadian registration for Salmosan® expired in 2003.

Veterinary drugs are another class of sea lice control products and are administered as feed additives. Ivermectin, a parasiticide commonly used in livestock to treat internal parasites, is not specifically approved for use in fish. However it was made available to veterinarians as an off-label prescription for fish in their care.[177] According to Dr. Man Sen Yong, Chief of the Human Safety Division of the Bureau of Veterinary Drugs in Ottawa, at the time ivermectin was being used in New Brunswick there was no research on how much drug residue remains in treated salmon, or how the drug affects marine ecosystems. He stated he would not have approved its use in salmon.[178]

As a feed additive, ivermectin is excreted unchanged, is toxic to a wide variety of invertebrate animals and degrades slowly in the environment, persisting in sediments for about a month. Uneaten feed on the sea floor can be ingested by bottom feeders such as lobsters and can accumulate in lobster tissue over several days. One study found that ivermectin is not well suited for the oral treatment of salmon lice infestations due to the resulting high concentrations of the drug in the central nervous system and its very slow excretion. Tests conducted over 27 days found that Atlantic salmon were very sensitive to the chemical with continual exposure through feed, with effects ranging from cessation of feeding and lethargy at lower concentrations to as much as 80 percent mortality at higher concentrations. Another test found that sand

shrimp died after ingesting ivermectin-medicated feed. The recommended withdrawal period, the time lag between treatment and marketing, for ivermectin-treated farmed salmon is 180 days.[179] [180] [181] [182]

In 1999, in the midst of another sea lice infestation, Health Canada received an urgent request from the aquaculture industry to approve Slice® as the next chemical weapon against the parasite.[183] The active ingredient in Slice®, emamectin benzoate (EB), is a member of the avermectin family and relative of ivermectin, and works as a neurotoxin which affects brain development and function.

Health Canada did not approve Slice® for general aquaculture use. Instead it made the drug available under the emergency drug release program for limited or emergency use only. To get an emergency release, a vet must apply to the Veterinary Drugs Directorate providing details of the infestation and the number and condition of fish to be treated. Approvals specify the withdrawal times between treatment and harvest in order to protect human health. Health Canada insists it is "cautious" in approving the release of emergency drugs. A BC salmon aquaculture spokesperson remarked, "It's used very infrequently by farmers."[184]

Yet, judging by the number of approved treatments, it is clear that Slice® has been used routinely for sea lice control on both coasts. According to documents acquired under the federal Access to Information Act by the British Columbia-based Raincoast Conservation Society, Slice® represented 38 percent of all animal drug prescriptions (terrestrial and aquaculture) in Atlantic Canada in 2001.[185] From 2000 through 2003 the Veterinary Drugs Directorate approved between 123 and 168 "emergency" requests each year from fish veterinarians. Quantities of Slice® Aquaculture Pre-mix provided to feed manufacturers (where it is mixed with regular fish feed and then sold as medicated feed to salmon growers) increased from slightly more than 2,000 kilos in 1999 to 7,000 kilos in 2000 and 2001, 10,800 kilos in 2002, and 10,500 kilos in 2003.[186] The numbers of fish treated with Slice® went from 10 million in 1999, to more than 38.5 million fish in 2001, more than 47 million in 2002, and over 37 million in 2003.

This increase in use of Slice® followed on the heels of a change in Health Canada's conditions for its use. Its original approval as an emergency treatment was conditional on no EB residues being found in farmed salmon during routine inspections by the Canadian Food Inspection Agency (CFIA). Yet in 2000, CFIA documents reveal that EB residues were consistently being found in New Brunswick farmed salmon, despite adherence to dosage and withdrawal period rules. Late in 2000, faced with the prospect of disrupting shipments of product or issuing a recall or consumer warning, Health Canada abandoned its 'zero tolerance" policy for residues and set the allowable limit for EB residues in fish tissue at 50 parts per billion (ppb).[187] The US Environmental Protection Agency sets a limit of 2 ppb of EB in meat. There are no US guidelines for residues in fish.

This residue problem is not surprising given the experience in Europe and Maine. In Canada, the withdrawal period for fish treated with Slice® is 25 days (compared to 180 days for its cousin ivermectin). This is one of the reasons it is so attractive to growers. However, in Norway and the Faroe Islands, EB has been found to be so persistent in salmon that the withdrawal period is 120 days – nearly five times longer. Tests on scallops in Cobscook Bay, Maine, found levels of EB three times the 2 ppb safety limit set by the US Environmental Protection Agency for residues in beef.[188] This reflects the drug's tendency to accumulate and persist in the marine sediments, leading to exposures of other species, especially filter feeders like scallops, mussels and clams.

According to the manufacturer's safety data sheet, emamectin benzoate (EB) "is toxic to fish, birds, mammals and aquatic invertebrates. Do not apply directly to water or to areas where surface water is present, or to intertidal areas below the high water mark."[189] While it is less toxic than ivermectin, several toxic effects have been observed in treated salmon. Scottish studies have found it to be lethal to mysid shrimp and that it can kill, cause deformities in, and interfere with moulting and reproduction in planktonic copepods.[190] DFO scientists have found that EB interferes with moulting and reproduction in lobsters. It is lethal to lobster at levels much higher than the recommended treatment dose; therefore lobsters are not considered at risk of dying from ingesting EB. However, ingestion of EB in lab experiments has triggered premature moulting in certain life stages of lobsters. Research is now investigating whether lobsters are likely to eat medicated feed pellets in the wild, and what effects multiple exposures to low doses of EB might produce. Other sub-lethal effects have not been fully investigated.[191] Meanwhile, fishermen have reported incidences of lobster moulting out of season in salmon growing areas. Mysid shrimp and copepods are the foundation of the marine food web, and lobsters are foundation of the commercial fishery, in the salmon growing region of the outer Bay of Fundy.

When fish farmers depend largely on one parasite control treatment, sea lice can develop a resistance to it. Evidence from Europe suggests this occurred with some products.[192] The manufacturer of Slice® recommends that it be used alternatively with other products to extend its useful life.[193]

This does not appear to be happening. Meanwhile, Health Canada has approved other sea lice treatments. Parasite-S® which controls external parasites has formaldehyde, a known carcinogen, as its active ingredient. Calicide®, with the active ingredient teflubenzuron,[194] is an in-feed sea lice treatment approved in 2002.[195] Teflubenzuron, the active ingredient in Calicide®, can persist in sediments for several months and is known to inhibit the formation of chitin, the primary component in the hard shell of crustaceans such as lobster, crabs and shrimp. Juvenile lobsters held near fish cages during treatment were killed by the exposure.

While some lab experiments have examined the effects of such pest control products on commercially important wild species, these tests generally focus on the active ingredient in the product. The active ingredient is part of a formulation which contains other chemicals, generally unknown, which have not been tested separately for their environmental effects. In the long-running spruce budworm spray program in New Brunswick, for example, certain so-called inert ingredients in the pesticide spray formulation were found to be more toxic than the active ingredient.[196] Further, there is no information on the effects of these chemicals on micro-organisms and plankton which form the base of the food chain in near-shore waters. There is also a lack of data on the cumulative effect on marine species of repeated exposures to a chemical, or exposure to a variety of chemicals cumulatively. Nor is there any understanding of the concentration and fate of aquaculture chemicals in the marine environment generally.[197]

Clearly, sea lice infestations continue to plague the salmon farming industry. Since the 1994-1996 crisis in New Brunswick for which nobody was prepared, using pesticides and drugs to control sea lice has become a routine part of doing business.

Metal contamination from fish farms

Metals are another contaminant from fish farms.[198] Copper is used in antifouling paints and on fish farm nets to inhibit the growth of algae and other organisms on fish farm structures, boat hulls and nets. It is also found in fish feed. Copper is highly toxic to aquatic organisms, may bioaccumulate in tissue, and may reduce the diversity of benthic animals. There are elevated concentrations of copper and zinc in sediments near fish farms in southwestern Bay of Fundy. In one study, 80 percent of samples at 9 of 10 sample sites exceeded the national sediment quality guideline for copper. Other metals such as zinc, iron and manganese are also found in fish feed, and cadmium, lead, copper and zinc may leach from metal cage structures. In sediments around fish farms in southwest New Brunswick, zinc concentrations have been found that exceed the national threshold effects level, and cadmium has been found at levels higher than is permitted for ocean dumping.[199] Radioactive dating of the sediment cores in Lime Kiln Bay in the L'Etang Inlet indicates that elevated levels of zinc and copper correlate with the introduction of fish farms into that area in 1981.[200]

In his report on chemicals in aquaculture from which this information is taken, Dr. L. E. Burridge writes,

All work reported here, and indeed reported in the literature, relies on a single species and single compound testing. There is a serious lack of data regarding the cumulative effect(s) of exposure to chemicals of aquaculture origin.... The source, concentration and fate of chemicals of aquaculture origin are poorly understood. The persistence of chemicals in sediment and biota, in most cases, is not known....Interpretation of [field] data is hindered by a lack of information regarding exact sample locations, [fish farm] production figures and [chemotherapeutant] treatment history at nearby sites.... While there are laboratory-derived data on many compounds mentioned in this brief review, there is almost no information regarding effects of chemicals of aquaculture origin in the field situation. [With respect to sea lice chemicals] [l]imited field trials have been conducted, but these studies have focussed on lethality of single treatments. Even these are inadequate in evaluating risks... Major questions remain regarding chemical contaminants related to aquaculture and their effects on the marine environment. Information is lacking on environmental trends and underlying ecological mechanisms. Investigating the potential effects of aquaculture chemicals is essentially an investigation of change.... Changes in biodiversity, for example, cannot be identified in short-term studies. Similarly, investigating effects of compounds on non-target organisms [other than sea lice] requires extensive understanding of the organism, its physiology and relationship to its environment.... Most non-target work addresses impacts on important commercial species. It is equally important to develop an understanding of other organisms that may serve as indicators of environmental health. This type of research is long term in nature.[201]

In short, we have no idea what aquaculture chemicals are doing to the coastal ecosystems into which they are discharged; however, there is enough evidence to conclude

that the health of the ecosystem into which these toxic chemicals are being released is at serious risk. Claims that there is no environmental impact are either misinformed or dishonest. Yet governments allow this industry to operate as if it is having no impact on the receiving waters and the plants and animals that live in them. This is unjustifiable and irresponsible.

Noise and light

The extent to which predators affect salmon farms is not well documented. Yet salmon losses from predation by local wildlife, i.e. seals, cormorants, great blue herons and ospreys is perceived as a significant problem. Nets, scarecrows and shooting are all used to deter these predators. Underwater noise makers, or acoustic harassment devices (AHDs) are specifically used to keep seals away from salmon cages.[247] AHDs emit sound at frequencies and intensities which are unpleasant to harbour seals, the most persistent and damaging predator. In a 1996 researchers visited all of the registered salmon farms in New Brunswick to measure for AHD sounds. Thirty-two of 69 sites were found to be using AHDs.[248]

Concern about the negative effects of AHDs on all marine mammals that frequent the waters of southwest New Brunswick has been slow to emerge. Fishermen have long been concerned about the effects of general noise from the salmon farms on herring but there is no research to quantify such impacts. The potential impacts of sound generated by these devices on marine mammals such as whales, porpoises and dolphins range from avoidance of habitat areas where AHDs are employed to, in extreme cases, loss of hearing. A field study done by DFO scientists in British Columbia found that the abundance of harbour porpoise dropped precipitously in the study area when an AHD was activated. The impact of the AHD extended beyond the 3.5 kilometres sighting range of the field study.[249] Similar research took place on Grand Manan in 1997.[250] There is anecdotal evidence suggesting that harbour porpoise distributions have changed recently in the Quoddy Region, the most intensive salmon farming region in the Bay of Fundy.[251]

The final report of the British Columbia Salmon Aquaculture Review Panel noted that AHDs[252] appear to lose effectiveness over time as seals and sea lions become accustomed to or deafened by them, or are so strongly motivated by hunger or previous success that they ignore the discomfort caused. The Panel declared AHDs to be generally ineffective and to pose a significant ecological hazard. It recommended that government phase out the use of all existing AHDs over a two-year period, during which time "predator prevention plans" be developed and implemented at each salmon farm.[253]

Other noise issues have emerged in recent years as the scale of operations has intensified. Automated feeders, generators, aerators and much larger scows and other boats tending the fish farms have created noisy neighbours for coastal land owners. Such disturbance is also likely to repel birds and other marine species that would otherwise use coves, inlets and bays for feeding, staging or as nurseries. The systematic disappearance of undisturbed coves along the lower Bay of Fundy has dramatically reduced the area of such habitat with unknown consequences. Landowners and tourism operators are also disturbed by such noise. One tourist cottage operator reported difficulty keeping clients because of the noise from the several salmon farms operating within a short distance of the cottages.

The use of lights on salmon farms is also a concern. Some operations use underwater lights to extend the number of hours salmon are exposed to light, thereby increasing feeding and growth rates. There has been no environmental impact assessment of either noise or lights associated with salmon farms, even though they both have the potential to seriously disrupt ecological processes including fish migrations. Herring on which the local weir and fish packing industries depend are known to be extremely sensitive to light.

Interactions with Wild Fish

The risks to wild salmon posed by salmon aquaculture have been formally acknowledged by the seven member countries of the North Atlantic Salmon Conservation Organization (NASCO)[202] of which Canada is one. NASCO meets regularly to assess the state of wild salmon populations and to develop strategies for restoring and protecting them. In 1994, NASCO members signed the "Convention for the Conservation of Salmon in the North Atlantic Ocean to Minimize Impacts from Salmon Aquaculture on the Wild Salmon Stocks." The Oslo Resolution, as the convention is called, cited three primary issues member countries should address. These were i) regulatory requirements for siting of salmon aquaculture operations (e.g. distance from salmon rivers; impacts on ecosystem); ii) management of aquaculture units to prevent and control diseases and parasites (e.g. fallowing, waste deposition); and iii) taking precautions to prevent escapes of fish (e.g. cage design standards). Nine years later, the World Wildlife Fund and Atlantic Salmon Federation published an evaluation of how the NASCO countries were doing vis a vis their 1994 commitments. Out of a possible score of 10, the highest rating went to Norway at 3.4. Canada scored only 2.85.[203]

In 1999, DFO reported salmon stocks in the inner Bay of

Fundy to be at an all time low. These are salmon that are unique to 33 rivers flowing into the head of the Bay of Fundy east of the St. John River. They are unique because their marine migration is local, with both post-smolts and adult salmon primarily utilizing the Bay of Fundy and the Gulf of Maine, including the area where salmon aquaculture is concentrated, rather than migrating to the Labrador Sea like other Atlantic salmon stocks. While the inner Bay of Fundy salmon have fluctuated in abundance over time, the most recent high population abundance was in the mid-1980s when the salmon aquaculture industry in the Bay of Fundy was just starting to take off. Returns to these 33 rivers "have declined to record lows during the 1990s and currently few wild Atlantic salmon of any age are present in the rivers of the inner Bay of Fundy."[204]

A fertile male farmed salmon captured on the Magaguadavic river, November 2005.
Photo credit: Atlantic Salmon Federation.

The Magaguadavic River salmon population is part of the outer Bay of Fundy stock. These fish migrate to the Labrador Sea and so do not spend as much time in the Bay of Fundy as the inner Fundy stocks. However, the river empties into Passamaquoddy Bay where several salmon farms are located, and there are three salmon hatcheries on the river itself. Between 1983 and 1988, fish ladder counts on the river recorded from 638 to 940 fish returning annually. Since 1992, returns had declined from 293 to only 31 fish in 1998, and then to 6 fish in 2003. Over the same period (1992-2003), egg deposition fell from 80 percent of the conservation requirement to 2 percent.[205]

In 2003, with many extirpations from natal rivers and wild salmon stocks having to be maintained by a gene bank, the inner Bay of Fundy salmon stocks were designated as endangered. Protections provided under Canada's new *Species at Risk Act* came into effect in June 2004. The outer Bay of Fundy stocks remain unprotected. Their immediate neighbours, salmon runs in six downeast Maine rivers near the epicentre of the salmon aquaculture industry in that state, have also been listed under the US *Endangered Species Act*. It is difficult to avoid the conclusion that the Canadian government is reluctant to do anything that might disrupt the salmon aquaculture industry, even if it means the possible extinction of the final remnants of the outer Bay of Fundy stocks.

The scientific recovery team established for the inner Bay of Fundy stock as required by the *Species at Risk Act*, has identified salmon aquaculture as a risk factor in the recovery of these stocks. A 2004 DFO report provided the context for the work of the recovery team:

The population has been in decline since 1990 and has varied from a peak of 40,000 mature fish in the 1970s to less [sic] than 200 wild adult salmon in 2003. Return rates from smolt to adult, an indicator of survival in the marine phase, has declined to extremely low levels relative to the 1970s and 1980s. Persistence of the population is currently maintained through the Live Gene Bank (LGB) program ... currently utilizing 11 rivers. The iBoF [inner Bay of Fundy] Recovery Team set the recovery target as the population distribution and abundance observed prior to the collapse in 1990; however, no time horizon for recovery has been estimated.[206]

The same report reviewed the potential sources of mortality or harm to the inner Bay of Fundy salmon to be addressed in any recovery plan. Of aquaculture, it states:

There are extensive salmon farming activities in the western Bay of Fundy that could affect the iBoF salmon. There are

many possible biological mechanisms for salmon farming to negatively impact iBoF salmon. Impacts may include occupation of habitat, increased incidence of ecto-parasites [sea lice] and disease, genetic introgression of non-native genes and increased presence of predators of salmon associated with farm operations. Measures are being taken to address a number of these potential effects [no description of these measures was provided.] Offshore aquaculture sites may also have direct impacts on iBoF salmon; however, no exhaustive assessment of potential impacts has been undertaken. The licensing of the transfer of salmonids between sites and introductions from other areas (importations) has the potential to affect iBoF salmon via direct consequences: e.g. disease and genetic introgression. Escapees and the establishment of non-native fish in the iBoF salmon may lead to the weakening of specific adaptations (in iBoF) or competition with native salmon. This impact of this type of introgression with native iBoF is estimated as high.[207]

DFO had already acknowledged that farmed salmon were mixing with wild salmon in the Bay of Fundy. While the industry is not required to report escapes from fish farms, occasionally incidents of cage breaches from which salmon have escaped become public. In September 1994, a storm damaged fish pens in southwestern New Brunswick allowing between 20,000 and 40,000 salmon to escape. In November 1998, 8,000 salmon escaped from a farm in the Annapolis Basin, Nova Scotia.[208] A Grand Manan salmon farm lost 15,000 fish when a storm damaged one cage in December 2000.[209] Four acts of vandalism on Cooke Aquaculture sites in May, August and November 2005 caused as many as 146,000 salmon to escape into Passamaquoddy Bay.[210] Two weeks after the November 2005 vandalism incident and at the height of wild salmon spawning season, Atlantic Salmon Federation staff had recovered 45 sexually mature escapees in Magaguadavic River.[211]

The Atlantic Salmon Federation (ASF) has documented the escape of over 350,000 farmed salmon into the Bay of Fundy between December 1999 and November 2005. Since reporting escapes is not mandatory, this number is probably low. While there has not been a comprehensive survey of Bay of Fundy rivers to detect escaped farm salmon, by 1999 escapees had been reported on 14 rivers in New Brunswick and Nova Scotia. In the Gaspereau River at the head of the Bay, hundreds of kilometres from the salmon aquaculture zones, farmed salmon made up 27 percent of the fish in one sample. Juveniles escaped from hatcheries servicing the aquaculture industry had been reported on four rivers.[212]

The Atlantic Salmon Federation (ASF) began research on the Magaguadavic River, in the heart of aquaculture country, in 1992. Besides its close proximity to the salmon aquaculture industry, there are three salmon smolt hatcheries in its watershed. Existing data from 1983, four years after the first salmon farm was established, found 5.5 percent of that river's salmon run was comprised of cultured salmon. In 1993, escaped farmed females spawned in the upper reaches of river, having passed through the fish ladder. The following year the number of escaped salmon exceeded the number of wild salmon in the river. In 1995 and 1996, adult escaped males were found in the river which could have spawned with wild females.

Since 1994, farmed salmon have made up an average of 75 percent of the salmon entering the river. In 1994 and 1995, the number was 90 percent or more (e.g. 1,910 of 2,120). Escaped parr from hatcheries were found in streams below or near commercial hatcheries. Samples of smolts leaving the river in 1996 and 1998 consisted of a low of 51 percent and a high of 82 percent hatchery escapees. Seventeen escaped salmon, five of which were sexually mature, were caught and killed In the St. Croix River on the western boundary of Passamaquoddy Bay in 1998. The situation in adjacent Maine rivers has been similar, with farmed salmon comprising more than 50 percent of the adult returns in the mid-1990s.[213]

ASF has also studied the occurrence of juvenile farmed salmon escaped from hatcheries on four fresh water bodies in New Brunswick. Escapes of juvenile salmon occurred in streams next to at least 75 percent of the commercial salmon hatcheries in New Brunswick. On the Magaguadavic River where escaped farmed smolts were found at all sampling stations in 1998-2005, escapee smolts outnumbered wild smolts in seven of eight years, and escaped farmed parr outnumbered wild parr in eight of 10 years. The two years where wild juveniles outnumbered hatchery escapees were accounted for by restocking programs. If the escaped farmed parr attain sexual maturity in the rivers, this would increase the risk of genetic introgression and thus a diminishing survival rate in hybrid offspring.[214]

On the North Atlantic feeding grounds where both northwest and northeast Atlantic salmon stocks migrate, escaped salmon from farms in Scotland, Ireland, Norway, Faroe Islands, Iceland and Canada, vastly outnumber their wild cousins. In Europe, escaped farmed females have destroyed wild salmon eggs by nesting on top of them, and spawning escapees have produced farmed and hybrid offspring that may then interact with wild offspring. Farmed and hybrid juveniles, while less robust, can be larger than wild juveniles, resulting in increased

competition or an imbalance in competition between age classes.[215] Further, while hybrid juveniles may out-compete wild juveniles, they tend to have lower lifetime survival, particularly in the second generation. Therefore, hybriding with farmed escapees will tend to reduce the fitness of wild populations.[216]

As post-smolts and adults migrate past aquaculture cage sites, their behaviour could change, perhaps affecting timing, route or homing of migration patterns. This is also an opportunity to pick up diseases and parasites and to be exposed to predators such as birds and seals which hang out around fish farms looking for an easy meal. There is evidence of lower survival rates of salmon post-smolts moving from Passamaquoddy Bay to the Bay of Fundy through a corridor filled with salmon farms compared to a route with lower cage site densities, suggesting that there is a relationship between the two. Tagging studies in 1995 and 1996 showed relatively high survival rates of smolts leaving Passamaquoddy Bay, but most losses of smolts and post-smolts occurred in areas near salmon farms.[217] Stocks that have short or coastal migrations, such as the inner Bay of Fundy stocks and repeat spawners from rivers adjacent to aquaculture sites, are at the greatest risk of such interactions.[218]

Transfer of disease pathogens

DFO's report on the interactions between wild and farmed salmon identified disease transfer as a potential risk factor for wild salmon, although it is known that wild fish harbour disease pathogens and could pass them to farmed fish. Diagnostic testing on limited numbers of fish from 1987 to 1998 found a number of disease pathogens in both wild and farmed salmon. Four other diseases were found in farmed salmon that were not found in wild fish.[219] One of those was ISA.

In October 1999, ISA was found in wild Atlantic salmon broodstock captured on the Magaguadavic River as part of a recovery program. Two of the 14 captured fish died quickly. Of the remaining 12, eight tested positive for ISA and had to be destroyed. Fourteen percent of the escaped farmed salmon captured on the river also tested positive for ISA. Wild Atlantic salmon stocks in the Bay of Fundy were at the lowest recorded level, with fewer than 30 spawning fish expected in that river that year, down from 31 in 1998.

Dr. Fred Whorisky, Vice-President of Research and Environment for the international Atlantic Salmon Federation based in Chamcook on Passamaquoddy Bay, was hopeful he could retrieve eggs from the uninfected fish, fertilize them and raise the offspring until they could be tested for ISA. Previous "vertical transmission" studies in Norway and Canada had shown that the virus could not be transferred from parent to egg. In a collaborative project with the industry and federal and provincial governments, Whorisky grew the offspring in a quarantine facility under strict bio-security controls. In June 2000, the experiment was over. About 10 percent of the salmon fry tested positive for ISA. None of the fry could be used in restocking programs for the Magaguadavic, representing an entire year-class of fish.[220]

According to Dr. Whorisky, fish diseases in the wild are natural. He noted, however, that the aquaculture industry, with its high density of cages and sites close together, provide ideal conditions for rapid transmission of a disease once it gets established on a fish farm. As water-borne disease pathogens travel from one fish farm to another wild fish can become infected. Infections can also be transferred when farmed fish escape and enter spawning rivers with wild salmon.[221] Even so, the DFO concludes, "The impact on wild finfish populations of infectious disease agents identified in the Maritimes is unknown."[222]

Sea lice

The effects of sea lice infestations on wild fish are of critical importance. In Scotland and Ireland, entire wild salmon and trout populations have been eliminated in rivers with salmon farms at their mouth. More recently, migrations of young salmon through British Columbia's Broughton Archipelago where salmon farms are densely packed have been devastated. In 2003, sea lice infestations on salmon farms were implicated in the loss of three million wild pink salmon. As the young salmon swim past infested farms the sea lice attach themselves to the wild fish and are rapidly transferred throughout the migrating run. While adult fish are able to withstand several lice without succumbing, the outward migrating juvenile salmon can be killed by as few as 3 or 4 lice.[223] DFO has refused to acknowledge what has clearly been demonstrated in other countries, or to lend credence to increasing volumes of independent research in Canada which makes the link between the decimation of wild salmon runs and sea lice infestations from salmon farms.

The sea lice and salmon farm controversy has been raging in British Columbia, with mounting scientific evidence of the devastating effect of sea lice on wild salmon smolts leaving their natal streams and swimming past the salmon farms crowding the bays into which salmon rivers flow.[224] In March 2005 a paper by research scientists at the School of Environmental Studies at the University of Victoria, and the Centre for Mathematical Biology at the University of Alberta was published in the Journal of the Royal Society in the UK proving the link between the loss of wild salmon and salmon farms. Co-author John Volpé called it the "smoking

Sea lice on pinks smolts.
Photo credit: Alexandra Morton.

gun." The study followed young salmon about the size of a triple-A battery as they left their natal streams and swam seaward past a salmon farm. Before the juvenile salmon reached the salmon farm, from four to 25 percent of the fish were infected, generally with just one louse. After passing the farm, 100 percent of the fish were infected with lice counts from 10 to 25 per fish. Two lice can be fatal to fish this size.[225]

The BC salmon industry response was predictable. An industry spokesperson simply stated, *"There are still a lot of unanswered questions…I don't agree that there is a body of evidence that is building against salmon farms. We will continue to do the work we need to do to assure the public this is a responsible industry."*[226] Two years later, monitoring has continued to show wild salmon smolts being ravaged by sea lice.[227] In May 2007, a special committee of the British Columbia legislature looking into aquaculture issues recommended a total transition from open net pens to closed containment fish farming systems in order to protect wild salmon stocks and marine ecosystems.[228]

The impacts of sea lice on wild Atlantic salmon in the Bay of Fundy is unknown, since there has been no research done on this on the east coast. While wild populations have declined precipitously since the early 1980s when aquaculture was established, populations had already declined to the point where the commercial salmon fishery in the Bay of Fundy was stopped in the 1970s. Yet despite dramatic reductions in fishing pressure both within the Bay of Fundy and on the North Atlantic feeding grounds since the 1970s, salmon populations have plummeted just as the aquaculture industry was growing.

Atlantic wild salmon have very different life histories than Pacific salmon and they are not as easily monitored as on the west coast. Monitoring for sea lice has not been done on salmon smolts traveling past salmon farms in the Bay of Fundy on their seaward migration.

The only sea lice monitoring was done by the Atlantic Salmon Federation. ASF counted sea lice on returning wild, farmed and land-locked salmon taken from a fish ladder trap in the Magaguadavic River from 1992 to 2002. Lice burdens on both wild and escaped fish increased over the course of the study to 2000, at which point they began declining. This timing corresponds with the introduction of Slice® as a sea lice control drug. At the height of the sea lice infestation (1994-95) few lice were reported on returning fish. The researchers speculate that this may have been due to high mortalities in the bay before the salmon reached the river. Lice burdens at levels which could have caused mortality did not appear to be causing significant damage to the infested salmon, possibly because they were recently infected and the lice did not have time to seriously impair their host. ASF cautions that the lice numbers may have been underestimated due to the fact that by the time fish entered the ladder, they may have been in fresh water for days or weeks, during which time they would have shed at least some sea lice (sea lice do not survive in fresh water).

Results for land-locked salmon were puzzling and troubling. These generally do not leave fresh water; however ASF found 14 tagged land-locked salmon in coastal waters beyond the river. Six of these traveled in the vicinity of fish farms. Two land-locked salmon returning to the river in less than two months had significant body damage caused by sea lice. According to researchers, "The damage caused to those fish suggests that levels of infestation that they bore would pose a mortality risk to out-migrant salmon smolts, which could contribute to wild salmon population declines in the region."[229]

While acknowledging the European experience that lice on farmed salmon contribute to lice populations in wild salmonid stocks (salmonids include trout), DFO has said of the situation in the Bay of Fundy, "Although there is the potential that any changes to lice levels could affect lice/wild salmon relationships, with the evidence currently available, it is not possible to conclude whether sea lice from farmed salmon do have any significant impact on wild salmon stocks."[230]

Atlantic Salmon Federation has publicly accused DFO of showing a bias towards the aquaculture industry to the detriment of wild stocks, stating that DFO's dual responsibility for protecting wild Atlantic salmon stocks and promoting the development of salmon aquaculture constitutes a conflict of interest.[231] ASF president Bill Taylor complained about "poorly regulated salmon aquaculture practices" along with several other factors responsible for the continuing poor returns to Bay of Fundy, Gulf of Maine and south shore Nova Scotia rivers that year.[232]

Genetic pollution and engineering

European and North American research has demonstrated genetic changes in cultured fish, such as increased growth rate, altered aggression and reduced response to predation. As these genetic changes manifest themselves through interbreeding, and where numbers of escapees relative to wild fish are high as in the Magaguadavic, a self-sustaining wild stock could be eliminated.[233] To address the issue of genetic pollution through inbreeding of wild and domesticated Atlantic salmon, there has been a call for the use of only sterile stock on fish farms. More recently, concern has been expressed over the possibility that escaped sterile males would still compete with wild males for mates resulting in failed reproduction and thus reduced numbers of fish in new generations.

One method of sterilizing salmon is through genetic engineering or biotechnology. Scientists at University of New Brunswick have been developing triploid salmon for two decades.[234] These fish have three instead of the usual two sets of chromosomes. The result is that their sex organs do not mature and the fish cannot breed. Triploidy is now used to induce sterility in a number of fish species.[235] Biotechnology is also being used to develop characteristics in Atlantic salmon and other aquaculture species that would enhance their commercial production.

Aqua Bounty Technologies, a biotechnology company headquartered in Massachusetts with operations in Newfoundland and Prince Edward Island, has developed transgenic (inserting genes from other species, in this case Chinook salmon) Atlantic salmon which grow from egg to maturity in 14 to 16 months. This compares to about 30 months for wild salmon and around 24 months for farmed salmon. Farmed salmon already grow faster than their wild cousins because they are regularly fed in a confined space, maximizing their food consumption and limiting their exercise capacity. The company's application to the US Food and Drug Administration for approval to commercialize their *AquAdvantage*™ salmon eggs is expected to be approved by 2009.[236] Application for approval in Canada was expected in 2005, triggering a review process that could take several years.[237]

Aqua Bounty Technologies has also succeeded in injecting into Atlantic salmon an "anti-freeze" gene found in cold water fish such as pout and flounder. So far, the transgenic salmon have not produced enough of the associated anti-freeze protein to increase its cold water tolerance significantly but once this is achieved it would allow salmon to be grown in colder waters and protect stocks from the risk of death from periodic "super chill" episodes.[238]

Public acceptance of transgenic fish is a big concern for the industry. As biotechnology food products have hit the marketplace over the past decade, genetically engineered or modified foods (GMOs) have become a hot button issue for governments, biotechnology industries and the public. The movement against GMOs or transgenic crops in Europe and strong pressure in North America to require labeling of GMOs (not yet in place) has prompted several food companies to stay away from them. Accordingly, as a pre-emptive move to protect their markets, Canadian aquaculture associations have denied any interest in farming so-called "Frankenfish."

Concerns about the ecological impacts of genetically modified fish have been raised in several circles. The Royal Society of Canada and subsequently the UK Royal Society, both independent science academies, called for a moratorium on rearing transgenic fish in marine cages, even while endorsing the development of transgenic research in other animals. They said approval for commercial production should be restricted to land-locked, secure facilities from which there is no danger of escape into the wild. They cited the fast-growing fish's voracious appetites (as much as a 250 percent increase in consumption rates) compared to wild salmon and the attendant problem of out-competing wild fish for food and habitat leading to negative ecosystem impacts.[239] The American Society of Ichthyologists also endorsed a moratorium on transgenic salmon.[240]

A study by Purdue University researchers demonstrated how transgenic fish (not salmon) out-competed wild males for female mates resulting in the genetically modified males being responsible for 75 percent of all matings. The offspring were less likely to survive compared to the natural counterparts. After crunching the numbers based on these results, researchers found that the entire fish population would become extinct within 50 reproductive cycles. Called the "Trojan gene effect", there is also the possibility that other species could be affected as well. A change in the gene pool could alter fish behaviour and therefore how the fish behaves in ecosystems.[241]

Aqua Bounty Technologies has responded to such concerns with some surprising corporate decisions. While denying the worst-case scenarios of ecosystem disruption from transgenic escapes, they position their product as a driving force for land-based closed containment fish farming systems which they call a "safer alternative" to the open net pens in coastal waters:

The debate seems to be set. Will transgenic salmon out-compete their wild kin and lead to loss of genetically unique wild stocks, or will transgenic salmon be less fit in the wild and transfer that trait to the wild population through cross-

breeding? At Aqua Bounty Farms, we believe there is another option: rearing the genetically modified fish in recycled water facilities, far removed from possible exposure to wild stocks…We are committed to the principle that Aqua Bounty licensees will grow AquAdvantage salmon in land-based systems, or will grow only sterile animals in ocean pens. While less preferable than inland farming, we believe it is more preferable to raise sterile AquAdvantage salmon in ocean pens than fertile standard Atlantic salmon. [242]

The advent of patented fish provides the patent holder with the opportunity to impose conditions on those who purchase their product. Aqua Bounty, at least at this early stage, appears ready to enforce very restrictive conditions through the licensing of producers. Whether they stick to this position once they hit the marketplace remains to be seen.

Land-based aquaponic systems for fish production are certainly environmentally preferable to open net pens in coastal waters and are advocated by many critics of open net pen aquaculture including the Conservation Council of New Brunswick. The benefits of these are as Aqua Bounty notes, the elimination of a number of risks inherent in ocean pens: storms, disease, predation, and water temperature, as well as the elimination of the discharge of tonnes of untreated wastes and chemical pollutants into coastal waters. Whether fast-growing transgenic fish will play a role in making these systems more attractive economically will depend, ultimately, on consumer acceptance.

Aqua Bounty has also taken another corporate decision. They will require *AquAdvantage* licensees to label their product as a biotech product. In Europe biotech labeling of food is already a requirement but not in the US. The company states,

Rather than raising an alarm, voluntary labels on biotechnology products help make the way in which the product was produced a non-issue with consumers – and with advocacy groups that might otherwise be quite vocal. The consumer is given control and choice, the producer or manufacturer is able to market the product without having to engage in drawn-out legal and media battles, and everyone wins. [243]

This corporate approach is very unusual. Rather than fight the battle head-on, Aqua Bounty is seizing opportunities that arise from the debates over both open net pen aquaculture and GMO foods to position their company and their product as close to the side of concerned citizens as possible.

5. Social and Cultural Sustainability: Conflicts within Communities

Conflicts with Traditional Fisheries

In May 1989, 21 angry lobster fishermen confronted the provincial Minister of Fisheries and Aquaculture with a petition objecting to the approval of a new salmon farm site. The site, developed by Norwegian-owned Sea Farms Canada Ltd. (later Stolt Sea Farm), was located on traditional lobster fishing grounds and spawning grounds for both lobster and scallops. Fishermen claimed they had already lost fishing grounds for 400-500 lobster traps in the same vicinity due to the expanding aquaculture industry. The new site would displace another 300-400 traps.

The fishermen also objected to the scale and rate of aquaculture expansion citing pollution caused by fish feed on the sea bottom, salmon morts (dead fish) and processing blood water being dumped into coastal waters (a contributor to disease transfer), and the loss of traditional fishing grounds to the extent that fishing was becoming "unfeasible". The letter accompanying the petition read, "We are willing to share the fishing grounds but are not willing to give them up altogether. It appears that is what the expansion of the aquaculture industry is heading for."[254] Both federal and provincial fisheries officials had assured fishermen, off the record, that the Sea Farm site would not be approved. The fishermen were understandably upset when it was.

This and similar conflicts between traditional fisheries and fish farming have continued within the restricted Bay of Fundy coastal zone. In a 1990 article, federal fisheries scientist Rob Stephenson characterized the conflict as "unusual in its intensity and scope... [I]n southwestern Bay of Fundy both aquaculture and traditional fisheries utilize a relatively narrow coastal zone. Since space is limited and utilization is high, there is increasing competition among users and greater potential for confrontation."[255]

The 1989 federal-provincial memorandum of understanding on aquaculture ceded any direct federal power over siting decisions to the provincial government, thereby marginalizing DFO's responsibility to protect fish habitat and fisheries in the fish farm siting process.[256] At the same time, the *Fisheries Act* provides neither explicit protection of access for commercial fishing in public waters nor any direct means of appeal when historic fishing access is displaced by a new development or resource user.[257]

Commercial fisheries are still the economic backbone of many Charlotte County communities with a combined value of approximately $120 million. Herring, lobster, scallops, ground fish and clams were historically harvested in the very territory where the salmon aquaculture industry has become established. Resource use maps of the West Isles – L'Etang – Passamaquoddy Bay area, the hub of the aquaculture industry, provide a visual demonstration of effects of aquaculture on other species and their habitats. While the full extent and impact of the lost fishing grounds has not been documented, many clam flats are closed to harvesting or impacted by algal mats, and many herring weir sites and shut-off coves are now occupied by salmon farms. Lobsters appear to have moved further offshore, and some scallop beds have disappeared.[258] Thus the issues raised by fishermen are not academic, but have come from direct experience of the sudden appearance and rapid growth of this industry in the midst of rich and historic fishing grounds.

Initially, concern for negative impacts of aquaculture on traditional fisheries was expressed by herring weir and shut-off fishermen (competition for space and interference with fish passage and distribution).[259] Eventually, many weir fishermen converted or sold their weir licences to salmon sites, preferring to profit from rather than fight the expanding aquaculture industry. This expansion soon began to infringe on other commercial fisheries. Lobster and scallop fishermen and clam harvesters raised concerns about changes in navigation patterns, loss of larval and nursery habitat for traditional species, and loss of fishing grounds. As the prospects of moving sea cages further out into open water arose, even fish draggers and herring seiners have expressed concerns about possible interference with their activities.[260]

In the early years, two fishermen's organizations were the most vocal on this subject. In 1990, the Charlotte County Clamdiggers Association (CCCA) and the Fundy Weir Fishermen's Association (FNFA) joined the Conservation Council in calling for strict regulatory controls on the salmon industry.[261]

Herring weir fishermen were concerned that salmon cages may block or divert herring migration routes, thus interfering with the ability of the stationary weirs to catch fish. Salmon wastes (offal and morts routinely dumped within coastal waters) and the permanent presence of live salmon (herring predators in the wild) may keep herring away from nearby weirs. They also cited competition for space by weirs and cage sites. According to a federal herring scientist, "we have yet to see a weir perform well in

close proximity to a major cage site."[262] Weir fishermen spokesman Jack Boone stated, "Aquaculture is the provincial government's baby, and you know how a mother will protect her children. The province has taken the stance that aquaculture can do no wrong, and you can't say it can do any wrong."[263] Two years later, Mr. Boone expressed frustration with the process of siting sea cages in a letter to DFO:

Once again we have been asked to comment on the thirty-two (32) proposed Aquaculture Site Applications. Unfortunately, in the past our comments have not had a favourable outcome, therefore we must once again advise those of you in the decision making process we are opposed to any site licences being given in an area which has enjoyed traditional fishing for Scallops, Lobster or Herring. We also point out our opposition to any site which interferes with the migratory pattern of fish and/or the blockage of any fishway. Although we have not assessed each site individually, we are prepared to assist any or all government departments involved with the final disposition of this matter. If you have any questions regarding this untraditional response, please call this office…

In September 1997, the Fundy North Fishermen's Association, representing lobster, scallop, and groundfish fishermen in Deer Island and mainland Charlotte and Saint John Counties, wrote in a brief to the Bay of Fundy Marine Aquaculture Site Allocation Policy Review, that fishermen have been on the water for years and notice very quickly environmental changes it takes scientists years to document. They have borne witness since "year one" to the

Excerpts from the Fundy North Fishermen's Association brief to the 1997 Site Allocation Policy Review

- *Fishermen have developed fishing plans based on aquaculture sites that were looked at and turned down. Some of these sites are now mentioned as being "reassessed." This is really disrupting our business and fishing plans and causing a lot of anxiety.*
- *Overcrowding leads to the use of pesticides and chemicals – any overcrowded species, whether fish, animals or humans, becomes sick. Sites licensed for 40,000 fish now have 200,000 fish plus. One large company doubled production last spring to "keep the same profit. We have seen morts from their sites go from 2 or 3 tote boxes every three days to 2-to-5 1,500 lb boxes every three days…*
- *Chemicals for treating sea lice have been proved this summer by independent researchers to kill all larval stage shellfish.*
- *Sites should be 3/4 of a mile apart. We observe grease slicks from sites travel about this far very noticeably. If the slick goes this far, it only stands to our reasoning that diseases, lice, etc., can travel between sites the same distance in the contaminants. In many cases, the grease slicks hold together and carry farther in the Fundy tides, not less.*
- *Cage boundaries should be strictly enforced and not allowed to be changed except after being advertised and reviewed by the site selection committee.*
- *Site selection should be an open process…All sites should be done this way, whether experimental, hospital or whatever, with no exceptions.*
- *The Fundy area should be broken into three groups or cells: a) aquaculture; b) limited aquaculture and fishing; and c) fishing. Fishermen also use "business plans." It's hard to plan ahead if we are not sure whether or not we will have the areas to fish in the coming years.*
- *In "B" cells [limited aquaculture and fishing] there should be a transparent process of site allocation with one year lead time so a year's fishing use could be documented. The most productive fall lobster grounds are usually the least productive spring grounds. Fishermen, together with DFO and DFA should be able to videotape the use of grounds in season.*
- *[Site allocation] advisory committee meetings should be open for interested people to attend. The advisory board should be made up of fishery association representatives, aquaculture association representatives, ecological group representatives and government departments. Decisions of advisory committees should not be overturned at the political level.*
- *The biggest problem the salmon industry suffers is poor site management. We observe that a lot of owners are no longer directly involved. It doesn't seem to matter if it is someone with one site, multiple sites or a large multinational company – poor choices are made because there is a feeling "the government will take care of me." There needs to be a weeding out of these parties which will only happen when the industry needs to stand on its own without government subsidies whether direct or indirect.*
- *The industry has reached its full potential and needs to be driven by ecological concerns to reach higher profits, not by physical growth. Just as the ocean cannot support overfishing, it cannot support an environmentally disastrous aquaculture industry.*

effects of aquaculture, "first in lost fishing grounds, nursery grounds, and spawning grounds, and then in later years in how shellfish and schools of fish have altered their patterns of behaviour."

At the same time, under the leadership of Edward McLean, then president of sardine processor Connor's Bros. Ltd., the herring fishery interests launched a focused effort to protect the weir industry from further incursion. In a position statement submitted to Fisheries and Aquaculture Minister Danny Gay in February 1998, the company noted that it, more than any other company, had a vested interest in the health of both the sardine and the aquaculture industries. Heritage Salmon began its life in the 1980s as a division of Connors Bros. Limited, and later was set up as a stand-alone company but both were under the Weston Foods umbrella. Yet the company saw that the sardine industry, specifically the herring weir sector which provides fish for processing during the summer months, was being increasingly squeezed by the expansion of salmon aquaculture:

The Charlotte County region has benefited significantly from the herring weir sector for over 100 years employing directly and indirectly in excess of 2,000 people….In the past few years, however, the number of active herring weirs has declined from approximately 242 to 188. This represents a significant reduction in the overall fishing effort. It is essential to Connors Bros. Limited, the herring weir fishermen and Charlotte County that… erosion of the number of active herring weirs be arrested to protect the long term economic viability of this fishery.[265]

Supported by the Fundy Weir Fishermen's Association and Grand Manan Fishermen's Association, the company sought the maintenance of the current number of herring weirs to meet processing production requirements. To achieve this, the company identified six productive weir areas where the aquaculture industry should not be allowed to expand. Further, to prevent herring weir sites from being sold to aquaculture interests, Connors Bros. wanted the sale of a weir licence to be contingent on the buyer building and actively fishing the weir within 12 months of the sale.

The government responded favourably to this unprecedented intervention by New Brunswick's most powerful fish processing company. An early draft of the new site allocation policy included several exclusion zones to protect the herring industry, but commitment to this wavered. In a strongly worded letter to Minister Gay dated May 26, 1999, Edward McLean wrote,

I have recently become aware of further revisions to the [site allocation] policy as regards to exclusion areas…Connors Bros. Limited's Canned Division is extremely disappointed and very concerned that this section of the policy has been removed….We feel the government is obligated to clearly state its position on future aquaculture growth opportunities in relation to the traditional fisheries. In our case, specifically the herring weir industry. Failure to do so is an abdication of your leadership responsibility in the fishery and will only lead to more ill feeling among the various interest groups….To have no exclusion zones to provide for the continued viability of the weir fishery and the sardine industry is totally unacceptable to Connors. We have too much invested in this industry to let the lack of clear government policy jeopardize our future.[266]

This intervention had some impact. When the new site allocation policy was unveiled in October 2000, Edward McLean praised it as a positive development. The policy stated that certain areas would be excluded "for eligibility for new Atlantic salmon aquaculture sites **at this time** [emphasis added]." Yet within these areas, boundary expansions and production increases for existing salmon farms "will be considered." The government's position on exclusion zones was far from firm. The policy states,

Over time these areas may be refined based on consultation with the aquaculture and commercial fisheries sector. A committee will be established consisting of representatives from the commercial fisheries, processing and aquaculture sectors, and the two levels of government to review and provide recommendations to the Minister of Agriculture, Fisheries and Aquaculture on modifications and refinement to exclusion areas.[267]

In 2001, five new salmon sites were approved and applications were invited for 2002. Some of these were along the southeast shore of Grand Manan. Fishermen on the island reacted angrily, blockading two wharves and threatening an escalation of their protest unless the Minister rescinded the approval of at least two offending sites. They said the salmon sites interfere with the lobster, herring and scallop fisheries, including one herring weir that had been operating since 1918.[268]

A DFO lobster expert confirmed the fishermen's view that one site was within a productive lobster area. Peter Lawton stated, "There are a lot of lobsters there, so if something did happen, whether it was a point-source chemical spill or some effect of medicated feed, you actually have a lot of lobsters there in the vicinity that could be affected. It becomes very much an issue of, what are the relative risks."[269]

The 14-hour blockade ended when the Minister of Agriculture, Fisheries and Aquaculture of the day, Paul Robichaud, agreed to meet with the angry fishermen. They traveled to Fredericton a few days later to express their concerns and to repeat their demand for a seat on the site evaluation committee. They came away empty-handed -- the Minister did not reverse his approvals – other than an agreement with government to study the issue of fishing displacement and impacts on lobster health of salmon farms in the area. The study showed that lobster fishermen were very concerned about the impacts of the farms on lobster health and habitat. The issue of displacement, while significant, was tempered by the fact that many fishermen are increasingly dividing their lobster fishing effort between inshore (where the salmon farms are) and offshore in deeper water. This raises the issue of future potential conflicts as the aquaculture industry looks to move sites out of the coastal zone into deeper, more exposed water.[270]

The herring weir industry, meanwhile, has called for a complete halt to aquaculture expansion, an expansion of the exclusion zones established by the 2000 policy, and a cap on the number of aquaculture sites to be allowed in this area. While refusing to impose a moratorium, the government did take some initiative to quell the discontent in the fishing industry. Besides the Grand Manan Aquaculture/Lobster Fishery Interaction Working Group formed in response to the blockades to oversee the study (above), a scallop working group was established in July 2001 to look at potential impacts of aquaculture on scallop beds on Grand Manan. Collaborative research projects were proposed, but agreement on how to proceed was elusive.

In February 2002, government stirred the pot by announcing that two new salmon farms were being considered for a rich scallop fishing zone where about six salmon farms were already established. Fishermen reported that 40 to 60 percent of scallops caught near the salmon cages were dead. Said Klaus Sonnenberg, general manager of the Grand Manan Fishermen's' Association, "It's going to cause utter war here. We had some pretty tense moments here last spring [during the 2001 blockade] and fishermen are just tired of this. They're getting pushed out. I'm really worried that if this goes ahead… some people will get hurt… and one of our most lucrative fisheries in New Brunswick will be destroyed." [271] No decision was made on those site applications and the issue of "clappers" – dead scallops – around existing sites has not been resolved.

Other working groups and forums were also struck. The Bay of Fundy Stakeholders Forum was established in October 2001 with a broad membership of fishing sectors, environmental and conservation non-profit groups, economic development agencies, First Nations organizations, aquaculture companies and associations, and federal and provincial agencies. Its mandate was to "foster and facilitate communications among the forum members and the aquaculture industry" and to "provide a forum to identify areas of concern among each group." The Forum, co-chaired by federal and provincial departments of fisheries and aquaculture, continues to meet twice yearly, yet it has evolved into strictly an information-sharing group and steadfastly avoids negotiating solutions to problems.[272]

The Southwest Herring Weir Retention Group was formed in January 2002, but only consisted of federal and provincial government representatives. This group proposed that a core protected group of herring weir sites be identified by the industry (between 125 and 175 weirs) and the provincial government would agree not to consider any application for a new or expanded aquaculture operation for these locations. It also proposed a formal process for reviewing the exclusion zones established in the Site Allocation Policy. The herring weir industry rejected this approach since it did not take into account shut-off fishing or herring migration routes, and it capped the number of weirs without also capping the number of aquaculture sites. This initiative stalled and has not been revived.

Meanwhile, tensions over site approvals continued. In 2002, all fishing sectors banded together to form the Traditional Fisheries Coalition. In June of that year, they collectively took the position that "a moratorium on all growth and expansion [of aquaculture] be implemented until concrete data can be collected to determine the impact of aquaculture on the traditional fishery within the Bay of Fundy."[273]

In August of 2002, the provincial government established the Bay of Fundy Exclusion Zone Review Committee to modify and refine the exclusion zones as set out in the Bay of Fundy Aquaculture Site Allocation Policy. With all fishing sectors and the aquaculture industry at the table, they agreed that "the development of aquaculture sites has reduced the physical space in which the traditional fishery can operate, and the fishing grounds that can be fished." Those participating in the traditional fishing industry feel "threatened by displacement and seeks assurance that, at least, the status quo regarding the extent of their activities can be maintained." Aquaculture representatives, at the same time, expressed their desire to continue to grow.[274]

Not surprisingly, the Exclusion Zone committee ended in deadlock. The status quo – maintenance of the exclusion zones as established in the site allocation policy – was

unacceptable to both parties. The aquaculture industry opposes exclusion zones as imposing an unacceptable constraint on their expansion. Fishery representatives, on the other hand, consider the current exclusion zones too limited, protecting only certain areas imperfectly and therefore not meeting their needs adequately.

In 2003, a salmon site application for Round Meadow Cove east of Dipper Harbour in Saint John County, the first site outside Charlotte County, brought these tensions to the forefront once more. Despite widespread community and fishery opposition, the site was eventually approved but before the approval was issued the applicant began building the site and using the local wharf without permission of the wharfinger. Altercations between fishermen and site workers erupted. Attempts by fishermen to block the movement of site construction materials from the wharf were thwarted by the RCMP, who refused to intervene in the illegal building of the site. A fisherman whose boat got tangled in lines at the site while fishing was arrested for cutting the lines, even though the site had not been issued a navigable waters permit which is a legal requirement for installing any structure or impediment in waterways.[275] Finally, after the site was constructed, government approvals were issued.[276] This episode underlined for everyone the unresponsiveness of both federal and provincial governments, and in many minds, the determination of government to allow the expansion of the aquaculture industry at any cost.

It is unreasonable to expect that either sector is going to voluntary limit its own operations. Yet the government continues to expect this to happen, and refuses to accept its own responsibility to limit access to public waters and resources. It steadfastly refuses to put a cap on the number of aquaculture sites it will approve, or the number of coves it will allow to be industrialized. By 2006, 70 percent of all coves and harbours between Saint John and Passamaquoddy Bay were filled with fish farms, occupying and displacing fishing grounds, degrading fish habitat, and dramatically diminishing the area of undisturbed coastline necessary for healthy ecosystem function.

Shoreline Degradation Sparks Community Conflict

When the Conservation Council launched its Fundy Baykeeper Program in May 2003, the most common public complaint received by the Baykeeper was the extent of garbage and debris on area beaches associated with the aquaculture industry. After a two-week survey of beaches in the Passamaquoddy Bay area, the Fundy Baykeeper delivered a message to the aquaculture industry at the annual Aquaculture Fair in St. Andrews the very next month. Standing by a truckload of small debris – feed bags, ropes, Styrofoam -- to visually demonstrate the problem, the Baykeeper presented to the media and industry reps a folio of photographs of large debris – abandoned fish cages, nets, scrap plastic pipe, metal walkways – on several beaches and public access points through Charlotte County. This led to high profile media coverage of the widespread use of public beaches and shorelines as dumping grounds for old equipment. It also led to an ongoing campaign by the Fundy Baykeeper to get the shorelines of Charlotte County cleaned up and rules in place for the use of beaches as staging and servicing points for aquaculture sites (see www.fundybaykeeper.org).

In 2003, Baykeeper David Thompson documented over 20 beach and shoreline sites where large debris from aquaculture sites had been illegally abandoned. Each year following the shoreline survey was repeated and results reported to environmental enforcement officials. Unless the owner of the debris can be identified, however, no order can be given to remove it. After another front page display of the aquaculture industry's mess in July 2005, the industry association asked its member companies to participate in an effort to clean up. Heritage Salmon responded by cleaning up several sites. The provincial government also became involved in a committee with salmon growers and local conservation groups to address the problem. By 2006, the situation had noticeably improved, but new sites and new debris on old sites are constantly appearing. This should be tempered by a new

Figure 14. *Telegraph Journal*, June 2003


TELEGRAPH-JO

SATURDAY • JUNE 14, 2003 Your province, your newspaper

BAYKEEPER MAKES A POINT

David Thompson, the Conservation Council of New Brunswick's Fundy Baykeeper, and Janice Harvey, the marine program director, say the aquaculture industry uses the bay as a garbage dump and are demanding a large-scale cleanup. Critics labelled Mr. Thompson's attention-grabbing display of garbage as showmanship.

Conservation Council 'theatrics' dump on Fundy salmon farmers

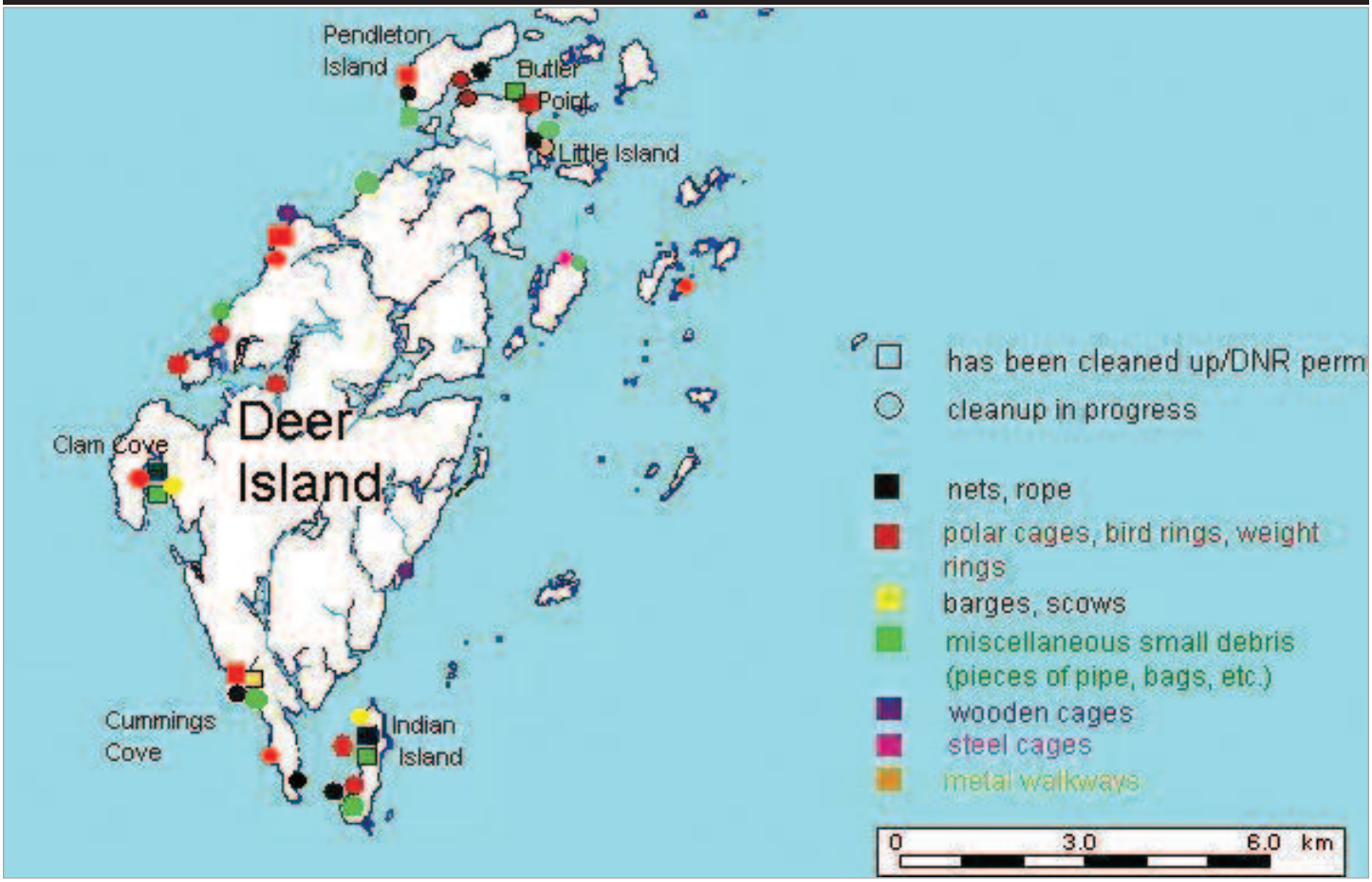
requirement imposed on the industry in 2007. Companies must now mark all their fish farm equipment to identify the farm site with which it is associated. This will allow the Dept. of Environment to take enforcement action as necessary.

Other high profile controversies have also led to policy and enforcement changes by the provincial government. In the summer of 2003, the Seal Cove sand beach on Grand Manan, a prime recreation area for residents and tourists, was taken over without authorization by Northern Plastics, an aquaculture cage manufacturer. The company worked on the sand beach all summer with trucks, tractors and front end loaders, placed large concrete moorings on the beach, and brought high powered boats into shallow water to tow assembled cages offshore. The RCMP investigated two incidents of damage to cars in the beach parking lot, and cars were frequently blocked from leaving or entering the parking area. The intervention of the Fundy Baykeeper led to the development of an operational policy by the NB Dept. of Natural Resources, the department responsible for managing activity in the intertidal zone, requiring companies to apply for a permit to use beaches for industrial activity.

A similar situation occurred on the beach at Little Dipper Harbour. In that case, the government issued a cease and desist order against company after the Baykeeper filed a complaint. Coastal landowners also complained about heavy trucks on the beach in Crow Harbour servicing the Penn Island salmon farm. When this site was shut down, the beach activity ceased.

These and other situations led the Fundy Baykeeper to call on the government to bring order to the chaos along the shorelines of Charlotte County. The industry had been operating with a sense of entitlement and a disturbing level of disrespect for adjacent landowners, recreational users of the shore, and for the public space within which they operate. Only after high profile exposure of the problem did the authorities acknowledge the problem and begin to deal with it.

Figure 15. Sites of abandonded aquaculture gear



This map, prepared in 2006 by a committee of government, industry and non-profit groups, identifies the sites in the West Isles alone where aquaculture companies have abandoned unused gear and equipment. Similar situations exist throughout Charlotte County.

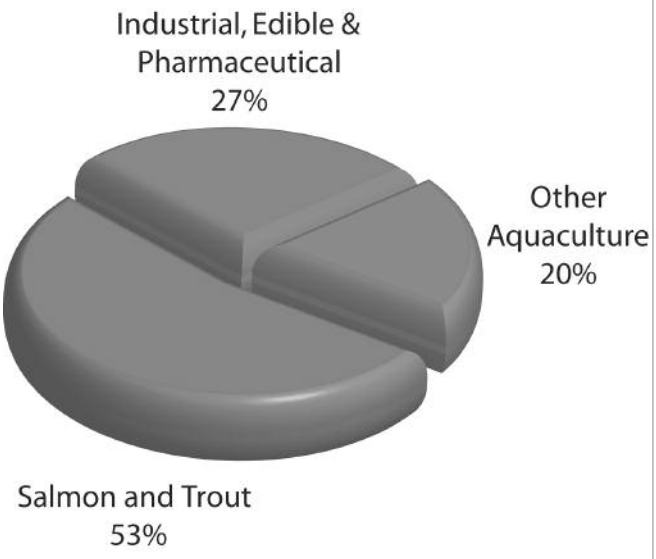
6. Global Sustainability: Beyond the Salmon Farm

Salmon Aquaculture's "Fishprint"

An issue rarely raised in connection with finfish aquaculture in New Brunswick relates to the broader claim of finfish aquaculture on the marine environment, referred to as its ecological footprint or "fishprint."[277] According to a British Columbia study, to produce one tonne of farmed Atlantic salmon requires primary productivity over 9.91 ha of ocean surface and 2.84 ha of terrestrial ecosystem.[278] Based on this calculation, producing 35,000 tonnes of farmed salmon on 1,500 ha of leased submerged land in the southwest corner of the Bay of Fundy requires ecosystem support in the form of primary production from a marine area of about 347,000 ha and a land area of 99,400 ha.

As carnivorous fish, salmon require feed containing fish meal and fish oil obtained from wild fish stocks caught in what is known as reduction fisheries. Small pelagic fish such as anchovy, jack mackerel, pilchard, capelin, menhaden, blue whiting and herring are the primary species harvested for the animal feed industry.[279] The United Nations Food and Agriculture Organization (FAO) estimates that 24 percent (32.2 million MT) of the total catch of pelagic fish is reduced to animal feeds.[280] While the total amount of fish converted to fishmeal has not increased in recent decades, the percentage of fishmeal and fish oil that is used in aquaculture has increased steadily.

Figure 16. Fish Oil Use in 2002



Source: WWF-Norway 2003

Globally, 46 percent of fishmeal and 81 percent of fish oil are used in aquaculture production, while the rest is used to produce livestock.[281] The salmon and trout industries consume 53 percent of the world's total fish oil production.[282] Modern salmon feed in British Columbia typically consists of approximately 30 percent fishmeal, 10 percent fish oil, 10 percent poultry by-products, 20 percent plant protein meals, 15 percent wheat, and 10 percent plant-derived oil (mainly canola), as well as vitamins, dyes, and chemotherapeutants (medication and / or parasiticides).[283]

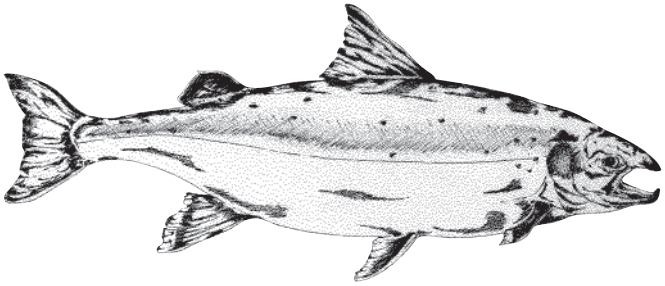
Since salmon feed is largely comprised of wild fish, the health of these stocks, both locally and in southern countries could become a major constraint on salmon aquaculture development. A reduction fishery developed in the Maritimes in the 1960s, resulting in the collapse of herring stocks in the Gulf of St. Lawrence. As a result, then-fisheries minister Romeo LeBlanc outlawed directed reduction fisheries. Instead, fish meal plants are to use food fishery by-products such as offal from processing plants. The herring roe fishery, which discards the entire carcass of the herring, is a source of fish meal for the feed industry in this region.

Feeding fish to fish results in a net loss of protein in the human food supply. More protein is used in salmon production than is produced by the salmon itself. It has been estimated that it takes four kg of wild-caught fish to yield one kg of farmed Atlantic salmon.[284] A Chilean report puts this ratio much higher, at 10 kgs of pelagic fish to produce one kg of Atlantic farmed salmon.[285] On a global scale, where protein is in short supply in many developing nations, using fish which are affordable and traditionally used for human consumption, to feed other fish species grown for distant high-end markets results in a significant net loss of protein and an inequitable redistribution of that protein.

The conflict between human need for fish and the global fish meal industry is very real. Jack mackerel is one of Chile's most important fish resources; 90 percent of the catch (2 million tonnes annually) is reduced to fish meal, while domestic consumption has fallen from 10 kilograms per capita per year to 4.5 kilograms.[286]

As more and more fish stocks decline, many consider aquaculture to be the solution to the feeding the world's burgeoning population into the future. Yet the FAO warns that these small pelagic fish now rendered into fishmeal to

How much wild fish is needed to produce 1 kg of farmed salmon?



1 kg of fish feed for salmon or trout consists on average of 280 g of fish oil. To produce 1 kg of fish oil, around 12 kg of wild caught fish is needed, depending on species and season. The average feed factor in Norway is 1.2 kg. To produce 1 kg of salmon:

280 g x 1.2 = 330.6 g of fish oil

330.6 g x 12 = 3967 g of wild caught fish

1 kg of salmon requires 4 kg of wild caught fish.

Source: WWF-Norway 2003

produce salmon will have to be redirected to human consumption if per capita seafood consumption is to remain steady at 13 kilograms per year as the world's population increases.[287]

The issue of conversion of marine species to feed salmon has an immediate potential to hit much closer to home. Herring wastes from the Scotia-Fundy roe fishery are already directed towards fish meal operations, an efficient use of a protein source that would otherwise go to waste.[288] However, there have also been anecdotal reports of rejected herring catches (because they do not meet size or quality criteria for processing) being diverted for fish meal with a much lower price paid to fishermen, as well as britt or juvenile herring too small for use as sardines being deliberately targeted for fish meal despite a federal law that prohibits fishing directly for use in fish meal production.[289] [290]

As the crunch for fish meal and fish oil supply looms, the aquaculture feed industry is trying to develop ways to reduce the content of wild fish content of feed formulations without affecting nutrition, taste and edibility for carnivorous fish. Increasing the percentage of plant-based proteins is one way of doing this. The industry is also considering using krill as a substitute.[291] Krill are tiny shrimp-like zooplankton that form the foundation of the marine food chain, the favourite food source for myriad bird, fish and mammal species. For example, abundant krill populations in the outer Bay of Fundy attract most of the endangered North Atlantic right whale population to this area to feed and nurse their young. As fish stocks have gone into decline, the phenomenon of "fishing down the food chain" has emerged. That is, as the higher species are fished out, commercial fisheries to exploit the next lower level in the food chain develop.[292]

In the 1990s, proposals for a commercial krill fishery in the Scotia-Fundy fishing region were submitted to DFO, with the market being the salmon feed industry. After some time and in the face of stiff opposition, DFO turned down the applications. Should an aquaculture feed market for krill open up, however, pressure to license a krill fishery in Atlantic Canada will grow. If that door is opened, it will be impossible to close again, short of disaster. A krill fishery would signal that the marine food chain has been fished to its literal end.

7. Postscript for an Unsustainable Industry

Despite the passage of 17 years, CCNB's 1990 analysis of problems and recommended measures for dealing with them continue to stand up to scrutiny (see Appendix A). The DFO-sponsored research project entitled "Environmental Studies for Sustainable Aquaculture" identified bay-wide eutrophication problems in certain Bay of Fundy salmon-farming areas, antibiotic resistant organisms in the vicinity of salmon farms, and high levels of other contaminants. Other recent studies from British Columbia, Norway, United States and Chile update and reinforce reports from the 1990s which shattered the myth of marine finfish aquaculture as a clean, sustainable industry which makes a positive contribution to world food supply.[294] Furthermore, the emergence of contaminants in farmed salmon as a consumer issue has sparked an industry-wide public relations effort to convince the public that their product is safe and that their critics have nefarious ulterior motives.[295] [296]

All this has prompted both the industry and its government promoters to begin using the term "sustainable aquaculture" to describe their operations and management programs. Yet neither has defined the term, nor addressed the fundamental ecological, social and economic issues that plague the industry. The regulatory and operational changes that have been made over the years have slowly ratcheted up the standards which the industry must meet, but the fundamental problems remain:

1) open net pen technology used in marine aquaculture allows wastes and contaminants to flow unimpeded and farmed fish to escape into the marine environment;

2) the large scale of today's fish farms results in the release of more wastes than the receiving waters can absorb;

3) the ongoing displacement of commercial fishermen from traditional fishing grounds and interference with other uses of the coastal zone creates serious community conflicts; and

4) the use of wild fish in fish feed results in a net loss of fish protein and extreme pressure on wild stocks which are important, affordable food fisheries especially in developing countries.

In October 1996, the David Suzuki Foundation in British Columbia released a report on the unsustainability of salmon aquaculture in that province. One of its key recommendations was to replace open sea cages with closed containment systems.[297] These would contain and treat wastes, prevent the spread of disease and parasites, recycle water, and prevent escapes. While more expensive, the real costs of farming fish would be internalized to the operation rather than being foisted onto the public through the degradation of public trust ecosystems. The Conservation Council has endorsed this position as have many other environmental groups around the world.[298] In May 2007 a report commissioned by the Province of British Columbia took this issue to the next step by recommending that salmon farms in British Columbia be required to move to closed containment systems within five years.[299]

The sustainable aquaculture imperative

The Bay of Fundy is New Brunswick's most productive and important marine resource, supporting a myriad of species, communities, livelihoods and human activities. Stewardship of the Bay of Fundy is a responsibility and an obligation. Indeed, New Brunswick markets the bay to tourists worldwide as "one of the marine wonders of the world." All industries located on or in the bay should be required to meet the highest of standards if this marine wonder is to be protected. Aquaculture should be no exception.

The Bay of Fundy aquaculture industry in 2007 has become an industrial food production monopoly that resembles and invokes the same problems as industrial hog, beef or chicken production. Like those livestock industries, industrial aquaculture will come under increasing marketplace and regulatory pressure to transform itself as awareness of the local and global environmental problems associated with large scale open net pen aquaculture grows.

The future is in sustainability, and with those governments and companies that dare to invest in aquaculture technologies, species and management systems that meet the objective test of sustainability as well as consumer expectations. It's time now to leave behind the excuses and public relations and move proactively towards production models in sync with the emerging realization that there are ecological limits which society ignores to its peril.

Appendix A

Conservation Council Marine Aquaculture Resolution, June 10, 1990

Whereas finfish aquaculture posed potential risks to native species of fish through disease and genetic pollution (crossbreeding with native wild species), and to other marine life through eutrophication, habitat degradation, and increased production of algae and phytoplankton; and

Whereas the 1989 waste discharge from aquaculture sites in the Bay of Fundy was equivalent, in terms of nitrogen and phosphorus discharge, to the untreated sewage of 60,000 people, and thus the Department of Fisheries and Aquaculture has licensed a raw sewage discharge of equivalent of 330,000 people (22,000 tonnes of salmon); and

Whereas finfish aquaculture requires significant inputs of pharmaceutical and biocidal chemicals; and

Whereas finfish aquaculture is being promoted in New Brunswick by the provincial government without due regard for the resulting environmental impacts;

Therefore be it resolved that the Conservation Council of New Brunswick demand that a moratorium be placed on finfish aquaculture until legally binding environmental controls are implemented. Specifically, the provincial government must amend Schedule A of its Environmental Impact Assessment Regulation to include aquaculture development, and promulgate a new regulation under its *Clean Environment Act* to control the discharge of nutrients, drugs and biocides, and to prevent the escape of genetic material and disease organisms from aquaculture sites. The regulation would include but not be limited to:

A. a prohibition on the chemical control of sea lice;

B. A requirement for the use of sterile stock;

C. the restoration of the 30,000 fish limit per licence.

Be it further resolved that Fisheries and Oceans Canada maintain the right to veto any aquaculture site proposal under its responsibilities for fisheries habitat management.

Be it further resolved that research be conducted to evaluate and promote the use of appropriate species to be cultivated in conjunction with finfish for nutrient uptake.

Be it further resolved that the Conservation Council campaign for the development of a coastal zone management plan to govern the development of coastal waters in New Brunswick.

Be it further resolved that the Conservation Council lend its support to commercial fishermen's organizations in their advocacy of policies and programs to sustain traditional fisheries.

This resolution was passed at the June 10, 1990 meeting of the Conservation Council Board of Directors.

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[4] The number of approved sites and active sites are not necessarily the same. Several companies have gone bankrupt in recent years with leases being taken over by other companies or abandoned. Other sites have been relinquished for new sites. Other leases can be inactive in any given year due to disease problems or economic factors. Exact information on such year-to-year changes is difficult to attain.

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[16] Weston's (2005). See notes 13, 14.

[17] Cox (2004). See note 11.

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[22] Cooke poised to dominate Atlantic industry: analyst. (2005, April 14). *New Brunswick Telegraph Journal*.

[23] Cooke acquiring Stolt assets. (2005, April 13). New BrunswickTelegraph Journal, and Rayner, B. (2004, April 12). Cooke Aqua takes over Stolt. *St. Croix Courier*.

[24] Glitnir. (2005, July 14) ISB Continues to Finance Salmon Farming Acquisitions in North America. Press release. "Islandsbanki is proud to announce that it has played a key role in two major acquisitions by Cooke Aquaculture within the past 14 months. In June Cooke Aquaculture, Inc. announced the acquisition of the Canadian east coast operations of Heritage Salmon from George Weston Limited, as well as the purchase of the U.S. operations of Heritage Salmon, subject to regulatory approval. Islandsbanki provided acquisition financing for this transaction. Islandsbanki first established a relationship with Cooke Aquaculture in 2004 when the bank provided financing for the acquisition of Atlantic Salmon of Maine. The announcement reinforces Cooke Aquaculture's commitment to the east coast salmon farming industry, and reflects Islandbanki's increased focus on the North American market. Islandsbanki's business in North America has grown steadily in recent years, and the outlook is bright, says Steinunn Thordardottir, Executive Director of International Corporate Credit. "Islandsbanki is a leader in the financing of many of the largest fishing companies in the region," she says. "We have recently seen increased consolidation in this industry to achieve economies of scale and we see that as an opportunity for us". Cooke has emerged as the largest Canadian-owned salmon farming company. These transactions will bolster the Company's competitive position in an industry that has faced serious challenges in recent years with managing fish health, market conditions, the rising Canadian dollar, and abnormally cold winters that have affected fish survival. "We believe the acquisition of Heritage Salmon will help to secure a long-term future for the east coast salmon farming industry," said Glenn Cooke, CEO of Cooke Aquaculture. The Heritage acquisition will provide Cooke with a strong sales and marketing team, the Heritage brand, additional aquaculture sites, and modern freshwater and plant facilities..."

[25] Salmon Farm Protest Group (2006, June 18). Press release. Retrieved from Salmon Farm Protest Group website: www.salmonfarmmonitor.org.

[26] Rayner, B. (2007, March 27). Cooke Aquaculture committed to Charlotte County. *St. Croix Courier*.

[27] Farmed salmon head to Newfoundland's south coast. (2007, April 4). The Coaster.

[28] Cooke Aquaculture completes a stage of its corporate strategy with feed plant acquisition (2007, July 25). *New Brunswick Telegraph Journal*.

[29] Maine Dept of Marine Resources. (n.d.) Retrieved April 2007

[30] Conkling, P. & Hayden, A. (1997). New England Aquaculture: A Case Study of Maine. In Goldburg, R. & Triplett, T. (1997). *Murky Waters: Environmental Effects of Aquaculture in the US*. New York: Environmental Defense Fund.

[31] Salmon farming fights for its life (2002, January 20). *Portland Press Herald*.

[32] Salmon farm to face charges (2002, January 19). *Bangor Daily News*.

[33] Bay alignment changes eyed to control ISA (2004, November 26). *The Quoddy Tides*.

[34] Duff, J. (2004). Salmon aquaculture struggles in Maine. The Coastal Society. *TCS Bulletin,* Vol 26 (4).

[35] Gov't of Nova Scotia (2005). *Growing our Future: Long Term*

Planning for Aquatic Farming in Nova Scotia. Discussion document. Nova Scotia Agriculture and Fisheries.

[36] Gov't of Nova Scotia (2005). See note 35.

[37] Gov't of Nova Scotia (2005). See note 35.

[38] Gov't of Nova Scotia (2005). See note 35

[39] Friends of Port Mouton Bay (n.d.) Retrieved April 30, 2007 from www.friendsofportmoutonbay.ca.

[40] Friends of Port Mouton Bay (n.d.) See note 39.

[41] The department has changed names several times since then. From Dept. of Fisheries, it became Dept of Fisheries and Aquaculture, then Dept. of Agriculture, Fisheries and Aquaculture. In 2006, two departments were created out of one, Dept. of Fisheries and Dept of Agriculture and Aquaculture. Each as a separate minister but the same deputy minister.

[42] Province of New Brunswick (1983). Aquaculture Development Policy. Technical Services Branch, New Brunswick Department of Fisheries.

[43] NB Dept. of Fisheries and Aquaculture (n.d.) *Meeting the Aquaculture Challenge*. Brochure.

[44] House of Commons Standing Committee on Fisheries and Oceans (1988). Aquaculture in Canada. Ottawa: House of Commons.

[45] (DFO). Dept. of Fisheries and Oceans (1991). *Aquaculture strategy for the 90s: Cultivating the future*. Canada: Minister of Supply and Services; and Dept of Fisheries and Oceans (1995). Federal aquaculture development strategy. Canada: Minister of Supply and Services.

[46] (DFO) Dept. of Fisheries and Oceans (n.d.). Retrieved from www.dfo-mpo.gc.ca.

[47] DFO (n.d.) See note 46.

[48] (OCAD) Office of the Commissioner of Aquaculture Development (n.d.). Retrieved from http://ocad-bcda.gc.ca/.

[49] OCAD (n.d.). See note 48.

[50] (OCAD) Office of the Commissioner for Aquaculture Development (2004). *Recommendations for Change*. Report to the Minister of Fisheries and Oceans Canada. Ottawa: Gov't of Canada.

[51] In 1999, the Conservation Council was twice invited as a witness before the House of Commons Standing Committee on Environment and Sustainable Development to speak to the lack of enforcement of federal legislation with respect to aquaculture. CCNB also presented evidence of the lack of regulation of nutrient discharges from aquaculture sites which can result in algal blooms and ultimately eutrophication of coastal waters. The committee's final report reflected many of CCNB's concerns and the committee initiated a process to propose amendments to the *Canadian Environmental Protection Act* to regulate the discharge of nutrients from fish farms. Immediately following the testimony of CCNB's science advisor Inka Milewski, she was approached by M. Bastien who stated emphatically to her, "The day groups like yours get invited to the table is when you stop taking these extreme positions." (Letter from Inka Milewski to Charles Caccia, Chair, House of Commons Standing Committee on Environment and Sustainable Development, February 05, 1999). The briefs presented to the Standing Committee can be read on the CCNB website: www.conservationcouncil.ca.

[52] (OCAD) Office of the Commissioner for Aquaculture Development (2001). *Legislative and regulatory review of aquaculture in Canada*. Ottawa: Gov't of Canada.

[53] (OCAD) Office of the Commissioner for Aquaculture Development (2003). Achieving the Vision: The 2003 Report of the Commissioner for Aquaculture Development. Ottawa: Gov't of Canada.

[54] OCAD (2004). See note 50.

[55] Feds urged to ease regulations for fish farms (2004, March 4). *Moncton Times & Transcript*.

[56] (CCNB) Conservation Council of New Brunswick (2004). *Response to the Report of the Commissioner for Aquaculture Development "Recommendations for Change"*. Unpublished. Available on CCNB website: www.conservationcouncil.ca.

[57] CCNB (2004). See note 56.

[58] Dept. of Fisheries and Oceans (2004, March 30). Minister Regan responds to OCAD recommendations. News release.

[59] Fisheries minister Hon. Geoff Regan appears to have been the first federal minister to publicly endorse the "smart regulation" philosophy, six months before a controversial report advocating the concept as defined by that committee was released in September 2004. The External Advisory Committee on Smart Regulation established by then Prime Minister Jean Chrétien in May 2003 consisted of 10 members, eight men and two women. Six were from the business/corporate sector. Others were from First Nations, academia, a government-funded sustainable development institute, and a consumers association. Its purpose, according to a committee fact sheet, was "to provide the government with an external perspective and expert advice on the best way to redesign the government's regulatory approach to create and maintain a Canadian advantage."

Since Canada's regulatory system is in place to protect the public, it would make sense that Canadians be consulted on such an important mandate. The committee describes its consultations thus: "...the Chair and members have canvassed the views of a number of federal departments and agencies, business organizations, consumer and environmental groups. Individuals and organizations had opportunities to share their views with the Committee at any time in writing or via the Committee's interactive web site [this is, of course, dependent on one being aware that the Committee exists and is developing proposals to redesign the way the government regulates business]. The Committee participated in an ongoing dialogue with provincial and territorial governments. Existing and commissioned research was used to help ensure its recommendations are relevant and helpful to all Canadians" (from FAQ, Frequently Asked Questions, provided by the Committee.)

The Canadian Environmental Law Association (CELA) notes that citizens groups specializing in environmental matters met with three members of the committee for three hours one day in July. CELA also provided a written brief and correspondence (one letter was signed by 45 organizations and individuals) on the priority of regulation to protecting the public interest, none of which was reflected in the final report.

The Committee's final recommendations, while couched in language about protecting public health, safety and the environment, focus single-mindedly on regulatory changes desired by the business and industry sectors to promote economic growth and trade. The report promotes streamlining regulatory processes within the federal government and between federal and provincial/territorial levels, further entrenching a "risk management" approach rather than a precautionary approach, and harmonizing many standards and regulations with the United States. This supports the "deep integration" lobby led by the Canadian Council of Chief Executives (CCCE, formerly the Business Council on National Issues), representing 150 of Canada's largest

companies. CCCE praised the report even before it was released.

According to CELA, "the report seems an almost perfect theoretical construct based on unsubstantiated assumptions and pleadings from special economic interests.... [T]he Advisory Committee's recommendations can best be summarized as Canada's version of 'no lobbyist left behind.' A very different approach, as suggested by the OECD in its recent (dismal) assessment of Canada's environmental performance, is needed to secure Canadians' long term well-being." (Letter to the Editor, The Hill Times, Oct 25, 2004). CELA's press release issued after the report was released stated: "The...report's core assumption is that regulation can be both 'protecting and enabling' at the same time. This assumption confuses government's regulatory roles B which have the approval of Parliament and ensure legal accountability B with promoting industry. Protecting the public is mandatory, and is the reason for regulation. The moment the promotional role is given a status equal to the regulatory role, the ability to protect public health, safety and environment is weakened. A proposed new Regulatory Policy would include a corporate-type 'pledge to Canadians' by government to 'ensure that our national regulatory system encourages innovation, market performance, competitiveness, entrepreneurship and investment in the Canadian economy'....This report seems to point to less accountability, more concessions to industry demands, and greater integration with the United States, all of which mean a weaker regulatory state in Canada. Such an approach seems anything but 'smart.' ("Report undermines protection of public health, safety and environment, groups say," CELA media release, September 28, 2004.)

On receiving the report, then-Prime Minister Paul Martin's office issued a news release which stated, "The Prime Minister has requested that the President of the Treasury Board, the Honourable Reg Alcock, in his role as the Minster responsible for the Government of Canada's Regulatory Policy, lead the development of a regulatory governance framework designed for the 21st century. Other Ministers will collaborate to improve and modernize regulation in areas such as natural resources, environmental protection, biotechnology, health, food safety and transportation." ("Prime Minister receives report on smart regulation from the External Advisory Committee on Smart Regulation," PMO News Release, September 23, 2004.)

In a follow-up letter to the Prime Minister, CELA wrote, "It is our understanding that various aspects of implementation will be carried out by departments having responsibility for a given policy area. We remain concerned about the pace at which this process is advancing, particularly as the default presumption is that smart regulation as envisioned in the [Committee] report is the appropriate starting point. It is also our understanding that PCO's [Privy Council Office] responsibility at this stage is to reconsider the direction of the Regulatory Policy. We look forward to the dialogue and will continue to press for an overarching protection mandate for the policy, which is at the core of federal regulatory culture and process. Such a dialogue is badly needed, because the [Committee] report clearly reflects only the viewpoint of one set of interests, namely proponents of industry, technologies and development projects. **We therefore urge you to send a message throughout government to halt smart regulation implementation until a national consensus is achieved on the appropriate direction for the policy, taking into account the views of those in science organizations, non-governmental organizations, regulatory departments, parliamentarians and ordinary Canadians.** [emphasis original]. Meanwhile CELA will continue to inform Canadians that the current dual-mandate approach compromises the regulatory responsibilities of the federal government." (Letter to The Right Honourable Paul Martin, October 22, 2004, signed by Paul Muldoon, Executive Director and Counsel, and Hugh Benevides, Research Associate, Canadian Environmental Law Association. Documents referenced in this endnote can be viewed at the following web sites: www.smartregulation.gc.ca. and www.cela.ca .

[60] This is a reference to the industry's longstanding lobby for a government-funded insurance program much like that of agricultural producers. The report recommends that the federal government "Develop and implement an aquaculture stock insurance program that provides coverage for extraordinary losses due to natural perils." (Recommendations for Change, p. 44). This is understood to include disease outbreaks which many would not characterize as a 'natural peril.'

[61] The section in the OCAD report on the environment begins, "It is clear that aquaculture is sustainable from both a seafood business point of view and a socio-economic perspective. What is less clear to some Canadians, however, is that aquaculture is also environmentally sustainable...Being nothing else than farming in the water, aquaculture should enjoy the same kind of support from Canadians. Up to now, this has been the case, as evidenced by several opinion surveys that have demonstrated a consistently large support from Canadians for aquaculture. Unfortunately, this support is current eroding due to a growing public perception that aquaculture is a polluting industry that puts our ocean environment and wild stocks at risk and markets fish that are unsafe for human consumption" (Recommendations for Change, p. 25-26.). In its submission to Minister Regan in response to the report, CCNB wrote, "This statement is indicative of the credibility problem from which the industry suffers. Its promoters will not concede that there are environmental sustainability issues related especially to marine finfish aquaculture. Instead, they continue to treat the issue as one of public relations (the need to 'educate' the public and counter 'misinformation'). This report is rife with denial and avoidance of serious environmental issues associated with the industry. Until they admit to and deal forthrightly with the problems, their credibility will be low." Regarding quality of fish, CCNB wrote, "The industrial livestock industry has been and will continue to be beset by controversy as governments fail to protect people from diseases and chemical contaminants inherent in the intensive production of protein, including fish....These are issues of substance, not public relations, and the government must be seen to be taking them seriously rather than dismissing or downplaying them. The public is not 'reassured' by governments that appear not to be taking issues seriously." (CCNB response to Recommendations for Change – note 53).

[62] Feds urged to ease regulations for fish farms (2004, March 4). *Moncton Times & Transcript*.

[63] Caccia, C., MP for Davenport, Chair of the Commons Standing Committee on Environment and Sustainable Development (2004, April 28). Letter to Hon. Geoff Regan, Minister of Fisheries.

[64] Regan, Hon. G., Minister of Fisheries and Oceans Canada (2004, June 7). Letter to Charles Caccia, MP.

[65] The exception to this is in the use of pesticides. The provincial Environment Department must issue permits for the use of all pesticides in salmon farming operations. Permits are only issued for pesticide products that have been registered for use in Canada by the federal government. However, individual users of pesticides need not apply for a permit. Instead DOE issues blanket permits to a single agency, for example the Department of Fisheries and Aquaculture, the NB Salmon Growers Association, or the Salmon Health Consortium, which covers pesticide use on all salmon farms. Individual applicators must take a training course in the safe handling of pesticides.

[66] This is a term which refers collectively to all drugs or other chemical treatments, including pesticides, which may be used to manage fish diseases and parasites.

[67] Province of New Brunswick, Aquaculture Act, Section 29.

[68] (NBDFA) NB Dept. of Fisheries and Aquaculture (1997). *The allocation and administration of marine aquaculture sites in the Bay of Fundy: A discussion of issues*. Fredericton: Gov't of New Brunswick. Despite referencing offshore sites, the final policy when it was released in 2000 was noticeably silent on this.

[69] NBDFA (1997). See note 68

[70] (CCNB) Conservation Council of New Brunswick (1997). Submission to the Bay of Fundy Marine Aquaculture Site Allocation Policy Review: Unpublished.

[71] Anderson, Hon. D. C., Minister of Fisheries and Oceans (1997, November 18). Letter to Hon. Donald Gay, Minister of Fisheries and Aquaculture, Province of New Brunswick. Mr. Anderson states: "I wish to confirm that I support the Conservation Council of New Brunswick's call for a moratorium on new salmon aquaculture sites, or on expanded operations at existing sites, while the [site allocation policy] Review is in progress." Mr. Neil Bellefontaine, Regional Director General of DFO's Maritime Regional office, also suggested a moratorium in a letter to Mr. Robert Gamble, Deputy Minister, NB Dept. of Fisheries and Aquaculture, September 22, 1997. He wrote: "I would suggest that we give consideration to a moratorium in new site allocations until this review is complete, given the comprehensive nature of the issues under consideration."

[72] Bellefontaine, N. DFO Maritimes Region Director-General (1997, September 22). Letter to Robert Gamble, Deputy Minister, NB Dept. of Fisheries and Aquaculture.

[73] Anderson, Hon. D. C., Minister of Fisheries and Oceans (1998, August 6). Letter to Charles Caccia, MP, Chair, Standing Committee on Environmental and Sustainable Development.

[74] (NBDAFA) NB Dept. of Agriculture, Fisheries and Aquaculture (2000). *Bay of Fundy Marine Aquaculture Site Allocation Policy*. Fredericton: Gov't of New Brunswick.

[75] Stephenson, R. L. (1990). Multiuse conflict, aquaculture collides with traditional fisheries in Canada's Bay of Fundy. *World Aquaculture*, Vol. 21(2), 34-45.

[76] Ross, J., Assistant Head, Southern Operations, Habitat Management Division, Maritime Region, Fisheries and Oceans Canada (1999, April 15). Attachment to letter to John Kershaw, NB Dept. of Fisheries and Aquaculture. Acquired through Right to Information request.

[77] More recently, individual site applicants have taken the initiative to provide application documents to the public when asked. This proactive gesture is a marked improvement in transparency and public relations.

[78] This report is unpublished but was based on the policy resolution passed by the CCNB Board of Directors in 1990 and is reprinted in Appendix A.

[79] Pollution charge upsets province's fish farmers (1990, June 23). *New Brunswick Telegraph Journal*.

[80] Pollution charge (1990, June 23). See note 79.

[81] Percy, J.A., Wells, P. G & Evans, A. J., Eds. (1997). *Bay of Fundy issues: A scientific overview*. Workshop proceedings. Wolfville, Nova Scotia, January 29 to February 1, 1996. Environment Canada - Atlantic Region, Occasional Report No. 8. 123-124.

[82] Hardy, R. W. (2001). Fish feed & Nutrition. Urban legend: are we one? *Aquaculture Magazine*. Nov/Dec: 52-56.

[83] DFO Science Branch, Maritimes Region. (2003). *Salmon holding capacity in southwestern New Brunswick*. Can. Tech. Rep. Fish. Aquat. Sci. 2489: iv + 60 p.

[84] Hardy (2001). See note 82.

[85] Lim, S. (1991). Environmental impact of salmon farming on the benthic community in the Bay of Fundy. *Bull. Aquacul. Assoc. Canada*. 91(3):126-128.

[86] Weston, G. P. (1990). Quantitative examination of macrobenthic community changes along an organic enrichment gradient. *Mar. Ecol. Prog. Ser*. 61:233-244.; and Homer, M. (1991). Impact of aquaculture on surrounding sediments: Generation of organic-rich sediment. In N. DePauw and Joyce, J. Eds., *Aquaculture and the Environment*. Ghent: European Aquaculture Society Special Publication No. 16., 155-75.

[87] Thonney, J. P. & Garnier, E. (1992). *Bay of Fundy Salmon Aquaculture Monitoring Program 1991-1992*. New Brunswick Dept of Environment and Environment Canada, Atlantic Region.

[88] Thonney & Garnier. (1992). See note 87.

[89] Weston (1990); Homer (1991). See note 86.

[90] Thonney, J.P. and Garnier, E. (1993). Bay of Fundy Salmon Aquaculture Monitoring Program, 1992-1993. Department of Environment, Province of New Brunswick.

[91] This interpretation would change in 2003 when a judge ruled in a case brought by the Conservation Council of New Brunswick that industry data submitted to government as a regulatory requirement is part of the public record to which citizens may have access. See Metz Farms vs. NB – 2002. Court of Queen's Bench of NB 394. Court file no. F/M/70/00.

[92] Garnier, E. (1997). *Bay of Fundy Salmon Aquaculture Environmental Management Project 1997 Final Report*. Prepared for the New Brunswick Salmon Growers Association.

[93] Garnier, E. (1998). *Bay of Fundy Salmon Aquaculture Environmental Management Project, 1998 Final Report*. Prepared for the New Brunswick Salmon Growers Association.

[94] (NBDELG) NB Dept. of Environment and Local Government. 2001. Environmental Management Guidelines for the Marine Finfish Cage Aquaculture Industry in New Brunswick, issued March 20, 2001. There is also a companion document which sets out standard operating practices for the environmental monitoring program described in the guidelines.

[95] For example, NBDELG has not established or imposed any water quality standards, or limits to any discharges into coastal waters. The approval only requires that dissolved oxygen and temperature measurements be taken bi-monthly. The operator must also record the amount of feed used in each one month period, and the nitrogen and phosphorus content of that feed.

[96] Hargrave, B. T. 2006. Science expert opinion on effects of free sulphides in marine sediments on macrobenthic infauna biodiversity. Expert Opinion 2006/01, Fisheries and Oceans Canada, Maritimes Region.

[97] Correspondence from Larry Murray, Deputy Minister, Fisheries and Oceans Canada, to Inka Milewski, CCNB Science Advisor, December 1, 2005.

[98] (NBDOE) NB Dept. of Environment. 2006. Environmental Management Program for the Marine Finfish Cage Aquaculture Industry in New Brunswick, Version 2.0, July 2006, p. 3.

[99] Notes taken by Janice Harvey, Marine Conservation Director, Conservation Council of New Brunswick, at the workshop, "Environmental Science Priorities in Support of Performance-based Management Approaches to Finfish Aquaculture," November 16-17, 2004.

[100] This site was the subject of intense opposition by adjacent landowners and fishermen. A court challenge of the temporary licence failed, but because of sustained opposition the provincial government maintained its original licence condition that the site would be temporary. The company then filed for a judicial review of the government's decision not to make the temporary licence permanent and lost. In that hearing, the poor environmental conditions on the site were cited by the government in defense of its position.

[101] (DFO) Dept. of Fisheries and Oceans. 2003. *Salmon holding capacity in southwestern New Brunswick*. DFO Science Branch, Maritimes Region. Can. Tech. Rep. Fish. Aquat. Sci. 2489: iv + 60 p.

[102] Stipanuk, M. H. 2000. *Biochemical and physiological aspects of human nutrition*, Philadelphia, PA: W. B. Saunders. This calculation is based on the best-case assumption that only dry feed is used (moist feed has higher nitrogen content), and uses the DFO figure of 32 kg N for each tonne of salmon produced. Also see Folke, C., Kautsky, N., and M. Troell. 1994. *The costs of eutrophication from salmon farming: Implications for policy*. Journal of Environmental Management, 40:173-182.

[103] Strain, P. M., Wildish, D. J., and Yeats, P. A. 1995. *The application of simple models of nutrient loading and oxygen demand to the management of a marine tidal inlet.* Marine Pollution Bulletin, 30(4):253-261.

[104] Strain et al 1995. See note 103.

[105] By 2005, the number of sites had been reduced to 22, the 1992 level. However, it is not clear whether production levels actually decreased in the area. Despite a moratorium on new sites and the abandonment of several sites during the ISA crisis, by 2000 when the moratorium was lifted, fish production had actually increased by nearly 40 percent.

[106] Pohle, G. W. and Wildish, D. J. 2004. "Benthic macrofaunal changes in the Letang Inlet: A quarter century view of an industrialized area," in Hargrave, B. T. ed. 2004. *Environmental Studies for Sustainable Aquaculture (ESSA): 2004 Symposium Report*. Can Tech. Rep. Fish. Aquat. Sci. 2542: vi + 81 p.

[107] Lim, 1991 and Pohle et al, 1994. See notes 85 and 106.

[108] *Premier's Round Table on Environment and Economy Aquaculture Working Group Recommendations*. 1998. Approved by the Round Table Plenary, June 23, 1998 and submitted by letter to Hon. Camille Theriault, Premier of New Brunswick, August 24, 1998.

[109] Hargrave, B. T. 2003. "Far-field environmental effects of marine finfish aquaculture." in Fisheries and Oceans Canada. 2003. A scientific review of the potential environmental effects of aquaculture in aquatic ecosystems. Vol. 1. Can. Tech. Rep. Fish. Aquat. Sci. 2450: ix +131 p.

[110] DFO. 2003. See note 101.

[111] Hargrave, B. T. Ed.. 2004. *Environmental Studies for Sustainable Aquaculture (ESSA): 2004 Symposium Report*. Can Tech. Rep. Fish. Aquat. Sci. 2542: vi + 81 p.

[112] Seven coastal management regions (CMRs) were delineated for the purposes of the study. These regions are characterized by hydrographic conditions. In general there is more water mixing within a region than between regions. The existing 22 aquaculture bay management areas established for management purposes are encompassed within the seven CMRs. This study indicates the bay management areas are too small to be effective because there is too much water exchange between them.

[113] Hargrave, 2003. See note 109.

[114] DFO, 2003, p.34. See note 101.

[115] DFO, 2003 pp. 42-45. See note 101.

[116] Robinson, S. M. C, Auffrey, L. M., and Barbeau, M. A. "Impacts of eutrophication on the intertidal zone in temperate areas with emphasis on the soft-shell clam, *Mya arenaria*,". in Hargrave, 2004. p. 56-58. See note 108.

[117] Robinson et al, in Hargrave, 2004. p. 56-58. See note 116.

[118] Hargrave 2004, p. 6. See note 109.

[119] Kepkay, P. E., Harrison, W. G. and Bugden, J. B. C. 2004. "Ecosystem indicators of water quality: II. Oxygen production and oxygen demand," in Hargrave, 2004, p. 46-47. See note 109.

[120] Lotze, H. and Milewski, I. 2002. *Two hundred years of ecosystem and food web changes in the Quoddy Region, outer Bay of Fundy*. Fredericton: Conservation Council of New Brunswick.

[121] Burridge, L. E. "Chemical use in marine finfish aquaculture in Canada: A review of current practices and possible environmental effects," in DFO 2003. See note 98.

[122] Salmon face new threat, *Telegraph Journal*, March 29, 1997.

[123] Stewart, J. E. 1997. Environmental impacts of aquaculture. *World Aquaculture*, March 1997, 47-52.

[124] (NBDFA) NB Dept of Fisheries and Aquaculture. 1997. The allocation and administration of marine aquaculture sites in the Bay of Fundy: A discussion of issues. Unpublished.

[125] Hammell, K. L. 1995. *An overview of furunculosis in Atlantic Canada*. Bull. Aquacul. Assoc. Canada. 95(3):8-11.

[126] Roberts, R. J. and Shepherd, C. J. 1990. Handbook of trout and salmon diseases. Oxford: Blackwell Scientific Publications Ltd., Alden Press.

[127] Stocking density is the mass of fish per cubic meter of cage space. In New Brunswick, the maximum stocking density allowed by licence is 18 kg per cubic metre.

[128] O'Halloran, J. and Henry, R. 1993. *Vibrio salmonicida Hitra disease*) in New Brunswick. Bull. Aquacul. Assoc. Canada 93(4):96-98.

[129] (NBDFA) NB Dept. of Fisheries and Aquaculture. 1994. Vaccination. Aquafacts No. 10, Gov't of NB, and NBDFA, 1994. Correspondence to aquaculturalists, November 7, 1004. Unpublished.

[130] Armstrong, S. M., Friars, F, Hargrave, B. and Haya, K. Microbial resistance to oxytetracycline in sediments from salmon aquaculture sites in the Western Isles region of the Bay of Fundy, in Hargrave, 2004. p. 19. See note 106.

[131] Stewart, J. E. 1994. "Aquaculture in Atlantic Canada and the research requirements related to environmental interaction with finfish culture," in Ervik, A., Kupka Hansen, P. and Wennevik, V. eds. *Proceedings of the Canada-Norway Workshop on Environmental Impacts of Aquaculture*. Bergen: Havforskningsinstituett.

[132] Hargrave, 2004. See note 111.

[133] Therapeutant Aquaculture Workshop, January 13, 1993. St. George, NB. Notes from a presentation by Adrien Gervais, Chief, Scientific and Technical Service. Dept. of Fisheries and Oceans, Ottawa.

[134] Results of veterinary drug, pesticide and chemical residue testing in New Brunswick farmed salmon from 1985-1996. Dept. Fisheries and Oceans, Ottawa. Obtained through Access to

Information request 1997.

[135] DFO testing did detect mercury (0.03 - 0.11 microgram/gram), dioxin (0.18 - 1.07 picogram/gram), and polychlorinated biphenyls - PCBs (0.16- 0.17 microgram /gram) in some samples. The most likely source of these persistent toxics is salmon feed, largely comprised wild fish. Locally produced feed consists of a combination of local herring and imported fish meal from South America. The issue of toxic contaminants in farmed salmon arose as a major consumer issue in 2002 and 2003.

[136] (NBDFA) NB Dept of Fisheries and Aquaculture. September 28, 1990. Memo from aquaculture veterinarian to DFA aquaculture coordinator, St. Stephen. Unpublished.

[137] Armstrong et al in Hargrave, 2004. p. 21. See note 130.

[138] Hargrave in DFO 2003. See note 109.

[139] Hargrave 2004, p. 9. See note 111.

[140] *Salmon coverage exaggerated and sensational,* Letter to the editor from Daniel MacPhee, President, Eastern Association of Aquaculture Veterinarians, St. Andrews, *Telegraph Journal*, September 27, 1997.

[141] *Battling a mysterious disease*, *Telegraph Journal*, August 23, 1997.

[142] Sea lice can also be carriers of *Aeromomas salmonicida* and thus potential vectors for furunculosis (Hodneland et al, 1993; Nese and Enger, 1993; Nylund et al, 1993).

[143] Salmon disease identified, *Telegraph Journal*, September 11, 1997.

[144] Salmon disease. See note 143.

[145] Information provided by NBDAFA, February 2005.

[146] This created a serious problem of abandoned large aquaculture debris on shorelines in the area which persists today.

[147] Intrafish.com Market Report Feature, 15/12/1999. The infection in Nova Scotia was in broodstock which was destroyed. Smolts from the broodstock had been transferred to three sites before the disease was detected and sampling of those sites found only a few diseased fish which were eliminated. Because salmon sites are far apart in Nova Scotia, the disease did not spread and has not re-occurred.

[148] Information provided by NBDAFA, February 2005.

[149] *Salmon company's assets for sale*. *St. Croix Courier*, January 6, 2004.

[150] Intrafish.com Market Report Feature on ISA. http://intrafish.com/englesk/report1999_32/feat01.php3.

[151] The Canadian Agricultural Income Stabilization Program (CAIS) and the Production Insurance programs are the two main programs under the Business Risk Management component of the Agricultural Policy Framework. The CAIS is designed to protect farm operations from drops in income. Production insurance provides farmers with financial protection against production losses caused by natural perils such as drought, hail, flood, frost, excessive moisture and insects. Insurance is only available on certain crops depending on the province (apples, canola, grains, potatoes, processing carrots, sweet corn, strawberries and wild blueberries in New Brunswick). The provincial and federal governments jointly contribute to all of the administrative costs of the program. Premium costs are shared between producers and both levels of government. From the website of the New Brunswick Dept. of Agriculture, Fisheries and Aquaculture – www.gnb.ca.).

[152] *Salmon bail out not enough: Growers*. NB.CBC.CA News, April 7, 2004.

[153] *New Brunswick salmon farmers offered millions in federal loans*. Intrafish 01/04/04.

[154] (NBDAFA) NB Dept. Agriculture, Fisheries and Aquaculture. 2005. *Joint salmon farming task force established*. News release, 25 January 2005.

[155] *Report of the task force on fostering a sustainable salmon farming industry for Atlantic Canada, April 2005*. Task Force members were: Fisheries and Oceans Canada; New Brunswick Department of Agriculture, Fisheries and Aquaculture; Newfoundland and Labrador Department of Fisheries and Aquaculture; Nova Scotia Department of Agriculture and Fisheries; Atlantic Canada Opportunities Agency; Agriculture and Agri-Food Canada; Business New Brunswick; New Brunswick Salmon Growers Association.

[156] (DFO) Dept of Fisheries and Oceans. 2005. *Federal government delivers on aquaculture investment*. News release, July 12, 2005.

[157] Nagasawa et al. 1993. Cited in British Columbia Salmon Aquaculture Review Summary, BC Office of Environmental Assessment.

[158] (NBDFA) NB Dept. of Fisheries and Aquaculture. September 22, 1995. Table (draft) on estimated sea lice losses. Obtained under *Right to Information Act*, July 31, 1997.

[159] *Sea lice cast pall over conference*. Sou'wester, September 15, 1995.

[160] In 1995, it cost about $41,000 per farm (based on an operation of 200,000 fish), to treat with hydrogen peroxide. For smaller cage sites, the cost was in the $15,000 range. In total, the industry spent $1.7 million on hydrogen peroxide treatments that year (NBDFA, 1995 – see note 155; Memo, 1995).

[161] Memo from N. Tolson to G. Laidlaw, Pest Management Regulatory Agency, April 7, 1995. Obtained under *Access to Information Act* request.

[162] Letter from G. Rawn, to G. Laidlaw, Pest Management Regulatory Agency, April 6, 1995. Obtained under *Access to Information Act*, July 31, 1997.

[163] Agriculture Canada. 1987. Aerial agricultural uses of synthetic pyrethroid insecticide. Bulletin No. 87-08. Pesticides Directorate, Ottawa.

[164] Undated memo from C. Kriz. EED opinion on cypermethrin. Pest Management Regulatory Agency. Obtained under *Access to Information Act*, July 31, 1997.

[165] *Salmon farmers' deadly chemical 'cookbook'*, *Saint John Times Globe*, October 12, 1996.

[166] Memo from S. Stehouwer, DPO Pesticides and Plant Products, Fredericton to Neil McTierman, RPO Pesticides, Moncton (PMRA), October 4, 1995. Obtained under the *Access to Information Act*, July 31, 1997.

[167] *Lobster suit launched*. *Courier Weekend*, October 25, 1996.

[168] This statement is misleading as comparisons between salmon farming and other types of food production are often not based on consideration of all aspects of production.

[169] Letter from J. O'Halloran, NBDFA to M. Farkas, PMRA, September 22, 1995. Obtained under the *Access to Information Act*, July 31, 1997.

[170] Dunier, M. and Siwicki, A. T. 1992. "Effects of

organophosphorus insecticides used against ectoparasites on immune response of Carp (*Cyprinus carpio*), "in C. Michel and D. J. Alderman, eds. *Chemotherapy in aquaculture: From theory to reality*. Symposium Paris, March 12-15, 1991. Paris: Office International des Epizooties, 141-151. Cited in Ellis, D. W. and Associates, 1996. Net loss: The salmon net cage industry in British Columbia. Vancouver: David Suzuki Foundation.

[171] Masseger, J. L. and Esnault, F. 1992. "Traitement par le Dichlorvos des copepodoses de la truite arc-enciel élevée en mare : Modalities de traitement adaptées aux conditions environmental francaises, » in Michel and Alderman 1992 and cited in Ellis 1996. See note 167.

[172] Aldermann, D. J., Rosenthal, H., Smith, P., Stewart, J. and Weston, D. 1994. *Chemicals used in mariculture*. Prepared under ICES Working Group Environmental Interactions of Mariculture, International Council for the Exploration of the Sea, Copenhagen, Denmark. ICES Cooperative Research Rept. No. 202.

[173] Staniford, D., 2004. "Silent spring of the sea," in Hume, S., Morton, A. Keller, B. Leslie, R, Langer, O, and Staniford, D. 2004. *A stain upon the sea: West coast salmon farming*. BC: Harbour Publishing, p. 165.

[174] At that time, azamethiphos, trade name Salmosan, was registered until December 31, 1997. At that point it would be re-registered pending receipt of environmental data from the manufacturer, Ciba-Geigy.

[175] Backgrounder prepared by G. Laidlaw, Pest Management Regulatory Agency, Ottawa, August 21, 1995. Obtained under the *Access to Information Act,* June 2, 1997.

[176] Burridge, L, Haya, K. and S. Waddy. 2004. "Chemicals to control sea lice infestations: What we know about their effects on lobster," in Hargrave 2004. See note 111.

[177] Off-label drugs are prescribed at a different dosage, through a different route, for a different species, or for a different length of time than those indicated on the label. The veterinarian takes professional responsibility for the drug's effectiveness and clearance from the fish.

[178] *Salmon farms investigated for drugging fish*. *Evening Times Globe,* September 26, 1995.

[179] Chang, B. ed. 1994. Biochemical indicators of health of aquatic organisms. Canadian Manuscript Report of Fisheries and Aquatic Sciences no. 2269. Cited in Ellis and Associates, 1996. See note 170.

[180] (DFO) Dept. of Fisheries and Oceans. 1996. Monitoring of sea lice chemicals in southwestern New Brunswick. DFO Science High Priority Project Final Report, 1995/96. Obtained under the *Access to Information Act* request.

[181] Hoy, T., Holberg, T. E., Nafstad, I. 1992. The disposition of Ivermectin in Atlantic salmon (Salmo salar), in Michel and Aldermans 1992. Cited in Ellis and Associates 1996. See note 165.

[182] (MAFF) BC Ministry of Agriculture, Fisheries and Food. 1995. Backgrounder: Sea lice update. October 23, 1995. Province of British Columbia. Cited in Ellis and Associates 1996. See note 165.

[183] CP Wire, Sunday, 12 December 2004, Byline: Amy Carmichael.

[184] The Daily News (Prince Rupert), Thursday, Dec 9, 2004, Byline: James Vassallo.

[185] Staniford, D. 2004. p. 186. See note 173.

[186] Cox, S. 2004. See note 11.

[187] Cox, S. 2004. The Cox report provides the following: Documents obtained under Access to Information legislation included a letter from Glenn McGregor, CFIA, to Gerard Lambert of Health Canada's Human Safety Division in which he wrote, "…we are consistently finding drug residues…We are prepared to sample and detain each shipment if necessary, but this will disrupt the orderly marketing of the product." In other correspondence, CFIA staff asked Health Canada if they should issue a recall or notify the public following the discovery of *emamectin benzoate* residues in farmed salmon. See note 11.

[188] Staniford, D. 2004, p. 184. See note 173.

[189] Staniford, D. 2004, p. 182. See note 173.

[190] Staniford, D. 2004. p. 184. See note 173.

[191] Burridge et al. 2004. In Hargrave, 2004. See note 176.

[192] National Working Group on Integrated Management of Sea Lice. 1998. Integrated pest management of sea lice salmon aquaculture Draft report, December 7, 1998.

[193] Cox, S. 2004, p. 25. See note 11.

[194] From Staniford, 2004 (see note 170): Teflubenzuron is a benzoylphenyl urea insecticide. It was "initially introduced in 1984 to protect fruit, vegetables and cotton. By the 1990s…chemical resistance was already being reported in land-based pests, so Nutreco (owners of Marine Harvest), in conjunction with the US chemical giant American Cyanamid, developed teflubenzuron (trade name Calicide) for aquaculture…. 90 to 95 percent of teflubenzuron ends up in the marine environment, mainly excreted through salmon feces. And as the Scottish government's Marine Laboratory stated in 2001: 'Once in the sediment, teflubenzuron could be available to the benthic community creating a possible passage into the food chain and the possibility of bio-accumulation.' As well as being potentially carcinogenic to humans, teflubenzuron is highly hazardous to the marine environment, especially shellfish. The chemical works by inhibiting the formation of chitin, which is the predominant component of the exoskeleton of insects and crustacean. It is therefore highly toxic to species that undergo moulting at any stage in their life cycle, including lobsters, crabs and some zooplankton species. A safety data sheet from the manufacturers, Cyanamid, warned in 1993 that teflubenzuron was 'Dangerous for the environment,' 'Very toxic to aquatic organisms' and 'May cause long term adverse effects in the aquatic environment'… The Scottish Association for Marine Science warned in 2001 [that] 'The chemicals used to control sea lice are highly toxic to crustaceans and are used by the salmon farming industry because of their efficacy at killing certain life stages of the parasitic copepods….Exposure of moulting stages to teflubenzuron and emamectin benzoate causes mortality and deformity at very low concentrations. Bioassay survivors displaying sublethal exposure effects [non-lethal] do not generally recover indicating that sea lice chemicals may exert significant ecological effects at concentrations well below indicative LC50 values and after only brief exposures."

[194] Cox, S. 2004. p. 22. See note 11.

[195] See Fairchild, W. L., Swansburg, E. O., Arseneau, J. T. and Brown, S. B. 1999. Does an association between pesticide use and subsequent declines in catch of Atlantic Salmon (*Salmo salar*) represent a case of endocrine disruption? Environmental Health Perspectives 107 (5):349-357; and McCormick, S. D., O'Dea, M. F., Moeckel, A. M., Lerner, D. T. and Thrandur Björnson, B. 2005. Endocrine disruption of parr-smolt transformation and seawater tolerance of Atlantic salmon by 4-nonylphenol and17_-estradiol. General and Comparative Endocrinology 142(3):280-288.

[196] Burridge, L. 2003. pp 98-99. See note 121.

[197] All information on these metals from Burridge 2003, note 121.

[198] Dumping of contaminated materials such as dredge spoils in the ocean requires an ocean dumping permit from Environment Canada. If the substance contains contaminants over certain concentrations (measured in parts per million or parts per billion), the permit is denied and the material must be disposed of on land in a secure landfill.

[199] Smith, J. N., Yeats, P. and Milligan, T. G. 2004. Geochronologies for fish farm contaminants in sediments from Lime Kiln Bay in the Bay of Fundy. In Hargrave 2004. See note 111.

[200] Burridge, L. 2003, p. 123. See note 121.

[201] These countries are Canada, Faroe Islands, Iceland, Norway, Scotland and United States.

[202] Porter, G. 2003. Protecting Wild Atlantic Salmon from Impacts of Salmon Aquaculture: A country-by-country progress report. Washington and St. Andrews: World Wildlife Fund and Atlantic Salmon Federation.

[203] (DFO) Dept. of Fisheries and Oceans. 1999. Interaction between wild and farmed salmon in the Maritime Provinces. DFO Maritimes Regional Habitat Status Report 99/1 E.

[204] Jones, R. A., Anderson, L. and Goff, T. 2004. Assessments of Atlantic salmon stocks in Southwest New Brunswick, an update to 2003. CSAS Res. Doc. 2004/019.

[205] O'Boyle, R. 2004. Proceedings of a Regional Advisory Process Meeting on the level of allowable harm for inner Bay of Fundy Atlantic salmon in support of species at risk. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2004/020.

[206] O'Boyle 2004. See note 206.

[207] DFO 1999. See note 204.

[208] New Brunswick Salmon Growers Association News Release, December 12, 2000.

[209] Data provided by Atlantic Salmon Federation.

[210] Atlantic Salmon Federation. 2005. Interactions between fertile farmed and wild salmon are cause for alarm. News release, November 23, 2005.

[211] DFO 1999. See note 204.

[212] DFO 1999. See note 204.

[213] Carr, J. W, and Whorisky, F. G. 2006. The escape of juvenile farmed Atlantic salmon from hatcheries into freshwater streams in New Brunswick, Canada. *ICES Journal of Marine Science*, 63: 1263-1268.

[214] DFO 1999. See note 204.

[215] McGinnity, P. et al. 2003. Fitness reduction and potential extinction of wild populations of Atlantic salmon, Salmo salar, as a result of interactions with escaped farm salmon. Proceedings of the Royal Society of London B. Biological Sciences, 2003, 270. p. 2443-2450. In a paper released in March 2003, entitled "Accidental and deliberate introductions of farm salmon result in reduced survival and fitness and could lead to extinction of vulnerable wild populations of Atlantic salmon," McGinnity and Ferguson conclude that "as a result of domestication over several generations, genetic changes have reduced the capability of farm salmon to survive in the wild, especially during the marine phase. Overall, [escaped] farm salmon showed an estimated lifetime success of 2% that of native wild salmon. In the second generation of hybrids, some 70 percent of the embryos died in the first few weeks....[G]enetic changes leading to reduced survival in the wild is a feature of all domesticated salmon and trout and consequently hybrids between farm and wild fish also have reduced survival."

[216] LaCroix, G. L., McCurdy, P., and Knox, D. Migration of Atlantic salmon postsmolts in relation to habitat use in a coastal system. Transactions of the American Fisheries Society, 2004. 133: p. 1455-1471.

[217] DFO 1999. See note 204.

[218] DFO. 1999. See note 204.

[219] Fatal disease found in wild salmon. *Telegraph Journal*, October 21, 1999 and ISA puts an end to salmon conservation project, *St. Croix Courier*, June 16, 2000.

[220] Salmon face new threat. *St. Croix Courier*, October 19, 1999.

[221] DFO 1999. See note 204.

[222] Hume, S. 2004. "Fishing for answers" in Hume et al. 2004. See note 173.

[223] See Morton, A., Routledge, R., Peet, C. and Ladwig, A. 2004. Sea lice (*Lepeophtheirus salmonis*) infection rates on juvenile pink (*Onchohynchus gorbuscha*) and chum (*Oncorhynchus keta*) salmon in the near shore marine environment of British Columbia, Canada. Can. J. Aquat. Sci. 61: 147-157. and Krkosek, M., M. A. Lewis and J. P. Volpe. 2005. Transmission dynamics of parasitic sea lice from farm to wild salmon. *Proceedings of the Royal Society of London*, Series B, March 2005.

[224] Team links farmed fish to outbreak. *Globe and Mail*, March 30, 2005

[225] Team. See note 225.

[226] Sea lice problem is growing, reports say; Several studies show that wild, juvenile salmon are now at greater risk. *The Vancouver Sun*, Sat 26 May 2007.

[227] The Legislative Assembly of British Columbia, Third Session, Thirty-Eighth Parliament. (2007). Special Committee on Sustainable Aquaculture, Final Report Volume 1.

[228] Carr, J. and F. Whoriskey. 2004. Sea lice infestation rates on wild and escaped farmed Atlantic salmon (Salmo salar L.) entering the Magaguadavic River, New Brunswick. Aquaculture Research, 2004, 35, 723-729.

[229] DFO 1999. See note 204.

[230] Catastrophic decline in Bay of Fundy stocks. *St. Croix Courier*, March 1997.

[231] Wild Atlantic salmon 'headed for oblivion.' *Telegraph Journal*, June 4, 2004. CP story.

[232] DFO 1999. See note 204.

[233] Benfey, T. J. and Sutterlin, A. M. 1984. Growth and gonadal development in triploid landlocked Atlantic salmon (*Salmo salar*). *Canadian Journal of Fisheries and Aquatic Sciences* 41(9):1387-1392.

[234] Scientists breeding eunuchs of the deep. *Telegraph Journal*, August 15, 1996

[235] See FDA may clear genetically enhanced salmon, Boston.com, March 10, 2005, and Aqua Bounty successfully completes key study for AquAdvantage Salmon, FDA accelerates review process. Aqua Bounties Technology press release, December 4, 2006, on www.aquabounty.com (visited August 2007).

[236] GM salmon approval sought. CBC-PEI website, posted December 8, 2004.

[237] This work is in association with sister company, A/F Protein, the world's only commercial producer of antifreeze proteins which are used for the control of cold-induced damage in medical, food and cosmetic products. See website: www.afprotein.com/.

[238] Royal Society endorses GM fish moratorium. Intrafish.com May 24, 2001.

[239] Stop the experiment. *The Globe and Mail*, March 16, 2001.

[240] Transgenic fish pose extinction threat. S. Mitchell, United Press International, February 17, 2004 found at the website of the Florida Museum of Natural History: www.flmnh.ufl.edu/

[241] "The Blue Revolution", found at www.aquabounty.com/blue.htm.

[242] "Biotech Acceptance: A label goes a long way," found at www.aquabounty.com/label.htm.

[243] Saunders, R. L. 1995. "Salmon aquaculture: Present status and prospects for the future.," in A. D. Boghen, ed. 1995. Cold water aquaculture in Canada. Second edition. Moncton: Canadian Institute for Research on Regional Development.

[244] Page, F. S. and S. Robinson. 1993. Salmon farming in the Bay of Fundy: A chilling reminder. World Aquaculture 23 (1993): 31-34.

[245] Hew, C. L. and G. Fletcher. 1997. Transgenic fish for aquaculture chemistry and industry. April 21, 1997. At http://ci.mond.org/9708/970812.html.

[246] AHDs are relatively high powered devices, e.g. >150dB, attached to permanent structures such as salmon farms or dams. Their purpose is to permanently displace marine mammals from their habitat, where those areas also contain operations with which marine mammals may interfere. Sound levels generated by AHDs are meant to induce fear and pain in order to deter seals from salmon farms, for instance. Acoustic deterrent devices (ADDs) are relatively low powered, e.g. <150dB, and are used on moveable, temporary fishing gear such as gillnets. Their purpose is to temporarily displace marine mammals from their habitat, for only as long as the gear is in place by alerting them to the presence of danger. An example is the Dukane pinger now being used to effectively deter harbour porpoise from gillnets. From Johnson, D. and T. Woodley. 1997. A survey of acoustic harassment device (AHD) use in the Bay of Fundy, NB, Canada. Submitted, Aquatic Mammals.

[240] Johnson, D. and T. Woodley. 1996. A survey of acoustic harassment device use at salmon aquaculture sites in the Bay of Fundy, New Brunswick, Canada. American Cetacean Society Conference, November 8-10, 1996, San Pedro, CA.

[241] Olesiuk, P. F., L. M. Nichol, P. J. Sowden, and J. K. B. Ford. 1995. Effects of sounds generated by an acoustic deterrent device on the abundance and distribution of harbour porpoise (*Phocoena phocoena*) in Retreat Passage, British Columbia. Unpublished manuscript.

[241] Johnston, D. W. Pers.comm. with J. Harvey, November 6, 1997.

[242] Gaskin, D. E. 1992. Status of the harbour porpoise, Phocoena phocoena, in Canada. Canadian Field Naturalist 106:36-54.

[243] The Panel incorrectly identified the devices as ADDs. Biologists define them as AHDs, however, to distinguish them from the less intrusive "pinger" type devices.

[244] British Columbia Salmon Aquaculture Review. 1997. Summary report. Victoria: British Columbia Office of Environmental Assessment.

[245] Aquaculture project has fishermen upset, *Telegraph Journal,* May 12. 1989

[246] Stephenson, R. 1990. Multiuse conflict: Aquaculture collides with traditional fisheries in Canada's Bay of Fundy. World Aquaculture 21(2): 34-35.

[247] There is some question whether the 1989 MOU was indeed legal, in that DFO may not have the authority to forego its legislated responsibility to protect fish habitat by withdrawing from active intervention in the aquaculture siting process.

[248] Common law does provide protection of rights of fishing and navigation through what is often called the public trust doctrine. See Kidd, S. 2007. *Keeping public resources in public hands: Advancing the public trust in Canada*. Fredericton: Conservation Council of New Brunswick.

[249] St. Croix Estuary Project, Eastern Charlotte Waterways Inc., West Isles Clean Environment Association, DFO Habitat Branch. 1995. Passamaquoddy Region Coastal Mapping Project.

[250] Weirs are large, stationary herring traps built perpendicular to shorelines and are dependent on herring migrations to catch fish. Shut-off fisheries use essentially the same approach although the gear is set up in a cove or inlet for a short period only and can be moved from cove to cove depending on herring migrations.

[251] Stephenson, 1990. See note 255.

[252] Statement prepared by the Charlotte County Clam Diggers Association for a press conference held by the Conservation Council of New Brunswick, June 20, 1990. Unpublished. President Larry Foster wrote: We are a traditional fishery that has been greatly reduced. We lost about 60% of our best clam beds in December 1988 [due to bacterial contamination]... [T]the industry was worth about $2,000,000 a year before the beaches were closed. It is worth about $200,000 the year after ....we had as many as 300 to 400 people working the beaches before the closures. I know that we have more diggers on welfare now. I suspect that our industry is going to be even worse off the more cages that go in. I hear that some scientists say that the added nutrients that are going into the water at the sea cages may be allowing more algae to grow. As I understand it, the algae make the Paralytic Shellfish Toxin. Does that mean that we will have more and longer closures caused by PSP? Given the run-around I've got from DFO over the last few years with no answers or help coming from them, I can do nothing but fully support the resolutions being put forward by the Conservation Council.

[253] Stephenson, R. 1990. See note 255.

[254] Aquaculture raises fears of bay time bomb, *Telegraph Journal*, June 22, 1990.

[255] Correspondence from J. Boone, Fundy Weir Fishermen's Association to [name deleted], Department of Fisheries and Oceans, St. Andrews, dated August 28, 1992. Obtained under the Right to Information Act, July 1997.

[256] Position Statement on the Sustainability of the Herring Weir Fishery, submitted to the Honourable Danny Gay, Minister of Fisheries and Aquaculture, Province of New Brunswick, February 19, 1998 by Connors Bros. Limited, Blacks Harbour, New Brunswick.

[257] Letter to Hon. Danny Gay, Minister of Fisheries and Aquaculture, Province of New Brunswick, signed by E. L. D. McLean, President, Connors Bros. Limited, dated May 26, 1999. Obtained through Right to Information request.

[258] Bay of Fundy Marine Aquaculture Site Allocation Policy, Province of New Brunswick, Department of Agriculture, Fisheries and Aquaculture, October 2000.

[259] "Lobstermen protest salmon farms, more fish farms to come in New Brunswick," The Canadian Press, May 24, 2001.

[260] "Biologist warns of threat to lobsters," The *Fredericton Daily Gleaner*, May 29, 2001. Byline: Campbell Morrison.

[261] Walters, B. 2007. Competing use of marine space in a modernizing fishery: Salmon farming meets lobster fishing on the Bay of Fundy. *The Canadian Geographer/ Le Géographe canadien* 51, no 2(2007) 139-159.

[262] "Scallopers fear damage to beds," *Telegraph Journal*, February 7, 2002. Byline: Chuck Brown.

[263] NB Dept of Agriculture, Fisheries and Aquaculture and Fisheries and Oceans Canada. 2005. Bay of Fundy Stakeholder Forum Terms of Reference. Unpublished.

[264] Bay of Fundy Exclusion Zones Review Committee Final Report, submitted to New Brunswick Department of Agriculture, Fisheries and Aquaculture and Dept. of Fisheries and Oceans by AMEC Earth & Environmental Ltd., Fredericton, New Brunswick, September 30, 2003.

[265] Bay of Fundy Exclusion Zones Review Committee Final Report.

[266] David H. Thompson, pers. comm. with J. Harvey.

[267] Approvals were granted despite information from federal fisheries scientists that the lease area provided good sea urchin and juvenile lobster habitat, and that at least a portion of the site was depositional, meaning it would not flush adequately. See "Meadow Cove proposed aquaculture site" prepared by Peter Lawton with assistance from Art MacIntyre, January 12, 2002 [sic – should read 2003], unpublished, and "Round Meadow Cove – Summary of DFO Science input," B. Chang, 30 Jan 2003. Acquired through Access to Information request.

[268] Wolowicz, K. 2005. Draft report, *The Fishprint of Aquaculture, Can the Blue Revolution be sustainable?* Redefining Progress, Oakland, CA, unpublished.

[269] Tyedmers, P. H. (2000). *Salmon and sustainability: The biophysical cost of producing salmon through the commercial salmon industry and the intensive salmon culture industry*. University of British Columbia, Canada. PhD dissertation.

[270] Tacon, A. G. J 2005. State of information on salmon aquaculture feed and the environment. Salmon aquaculture dialogue. WWF US: 80.

[271] FAO. 2004. The state of world fisheries and aquaculture. 2004. Rome, Italy, Food and Agriculture Organization of the United Nations.

[272] Tacon, 2005. See note 279.

[273] Tuominen, T-R, and Esmark, M. 2003. *Food for thought: the use of marine resources in fish feed*. Report no. 02/03, February 2003. WWF-Norway.

[274] Peter Tyedmers, 2007, pers. comm. with Jen Ford.

[275] Tuominen and Esmark. 2003. See note 282. A slightly lower estimate – 3.2 kg of pelagic fish per 1 kg of salmon – is found in an early report: Naylor, R. L., R. J. Goldberg, J. H. Primavera, N. Kautsky, M. C. M. Beveridge, et al. 2000. *Effect of aquaculture in world fish supplies*. Nature 405: 1017-1024. and Tyedmers, P., 2000 (note 278).

[276] Pinto, F. and Furci, G. 2006. *Salmon piranha style: Feed conversion efficiency in the Chilean salmon farming industry*. Terram Publications, APP 34 English version.

[278] Kearney, J. 1993. Restoring the common wealth of ocean fisheries: A discussion paper oriented toward enlarging the concept of sustainability in the deliberations leading to the UN Conference on Straddling Stocks and highly Migratory Fish Stocks. Conservation Council of New Brunswick Occasional Paper. Unpublished.

[279] (FAO) Food and Agriculture Organization of the United Nations. 1995. The state of the world fisheries and aquaculture. FAO Fisheries Department. Rome: FAO. Cited in Goldburg, R. and T. Triplett. 1997. Murky waters: Environmental effects of aquaculture in the US. New York: Environmental Defense Fund.

[280] The roe fishery itself is controversial since a directed fishery for egg-bearing herring has the potential to affect replenishment of the herring stocks themselves. Many believe herring stocks should be allowed to reproduce before harvesting.

[281] By 1990, one local feed manufacturer was using over 30,000 tonnes of Scotia-Fundy herring (Cook, 1990).

[282] This prohibition was enacted after dramatic herring stock collapses due to heavy fishing pressure to fill fish meal markets in the 1970s.

[283] "Researchers try krill feed experiment (Norway)," www.FIS.com, May 22, 2002.

[284] Lotze, H. and Milewski, I. 2002. *Two hundred years of ecosystem change in the Quoddy Region, outer Bay of Fundy*. Fredericton: Conservation Council of New Brunswick.

[285] Hargrave, B. T. ed., 2004. See note 111.

[286] Tyedmers, P. H. (2000); Naylor, R. L et al, (2000); McGinnity, P. et al (2003); Hargrave, B. T. ed. (2004). See also, Tuominen, T-R and M. Esmark, (2003).

[287] See endnote 61.

[288] According to Salmon of the Americas, representing salmon producers in North and South America, "[A]quaculture…has been the subject of many intensive environmental assessments. These assessments have consistently found that aquaculture poses a low risk to the environment and its environmental impacts are localized, temporary and fully reversible through natural processes. The industry works continuously with governments to ensure aquaculture remains a sustainable and well-managed component of the coastal economy and environment… Salmon farming is a safe and eco-friendly answer to the worldwide demand for fresh salmon year-round. The industry goes to great lengths to protect the environment and natural sea life from any farming impacts." Salmon of the Americas website, http://208.106.249.88/oceanfarming/aquaculture.cfm. Visited August 23, 2007.

[289] Ellis, D. W. and Associates. 1996. Net loss: The salmon netcage industry in British Columbia. Vancouver: The David Suzuki Foundation.

[290] See www.puresalmon.org; www.farmedanddangerous.org; www.davidsuzuki.org.

[291] The Legislative Assembly of British Columbia, 2007. Special Committee on Sustainable Aquaculture final report, Third Session, Thirty-Eighth Parliament. Available at: www.leg.bc.ca/cmt.