SALMON AQUACULTURE IN BRITISH COLUMBIA
A HISTORY AND COMPARATIVE ANALYSIS

by

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ABSTRACT

Salmon farming is a relatively new industry that has expanded rapidly, particularly over the past twenty years in several maritime countries. This industry offered promises of economic growth and job opportunities, as well as a way to diversify national economies and feed the world's growing population. However, such rapid growth has not come without costs. Worldwide, the industry was permitted to expand without adequate research into potential environmental impacts and associated regulations or guidelines. Over time, however, real and perceived impacts from salmon farming have affected public acceptance of farmed salmon and have forced governments to examine and revise regulatory strategies.

This paper examines the history of salmon farming in British Columbia (B.C.), discusses key issues that plague the industry and identifies current management practices in B.C., Norway, Chile, Scotland, and Washington State. It also documents the inadequate regulatory framework in B.C. that led to a moratorium in 1995 on the approval of new sites, and the initiation of a salmon aquaculture review. This is followed by a summary of the recommendations and conclusions presented in the review, and an analysis of measures taken subsequently to better manage the industry. A comparative analysis is provided of salmon farming practices in all jurisdictions examined in this study.

Regulation and management of salmon farming in B.C. appears to be more developed than in the other jurisdictions. However, there are still significant steps that should be taken to ensure the future viability of the industry. Recommendations to improve management of the industry and prevent or mitigate adverse environmental impacts emerged from the comparative analysis of salmon farming practices. It is suggested that sustainable management of the salmon farming industry in B.C. will only occur through a cooperative multi-stakeholder approach to decision making, implementation of integrated coastal management, and a greater emphasis on basic scientific research.

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LIST OF ACRONYNMS

APP	Aquaculture Partnership Program
BCSFA	British Columbia Salmon Farmers Association
CAIA	Canadian Aquaculture Industry Alliance
CEAA	*Canadian Environmental Assessment Act*
DFO	Department of Fisheries and Oceans
DOE	Washington Department of Agriculture and Ecology
DSF	David Suzuki Foundation
EAA	*Environmental Assessment Act*
EAD	Environmental Assessment Document
EAO	Environmental Assessment Office
ICM	Integrated Coastal management
ISO	International Organization for Standardization
LRMP	Land and Resource Management Process
MAFF	Ministry of Agriculture, Fisheries and Food
MELP	Ministry of Environment, Lands and Parks
MSC	Marine Stewardship Council
NASCO	North Atlantic Salmon Conservation Organization
NASFI	North Atlantic Salmon Farming Industry
NMFS	U.S. Department of Commerce, National Marine Fisheries Service
SAR	Salmon Aquaculture Review
SEPA	Scottish Environmental Protection Agency
TAT	Technical Advisory Team
WDFW	Washington Department of Fish and Wildlife

Chapter 1 INTRODUCTION

1.1 Background

Since the inception of salmon farming in British Columbia (B.C.) in 1984, this industry has expanded significantly and has caused considerable controversy due to its perceived biophysical, social, and economic impacts. While salmon farming represents a significant economic contribution to the province, there has historically been little regulation of the industry. In an attempt to address these impacts, the provincial government conducted an extensive review of salmon farming in B.C, which was released in August 1997. The recommendations resulting from this study are controversial, and no consensus has been reached on their effectiveness at creating a sustainable salmon farming industry in B.C.

In 1995, the value of farmed salmon more than doubled that of B.C.'s commercial salmon fishery. By 1998, the salmon farming industry contributed $613 million to the B.C. economy, providing 1,675 direct and 1,460 indirect jobs. Ninety percent of these jobs exist outside of Vancouver and Victoria. Farmed salmon is B.C.'s largest agri-food export crop and fourth largest agricultural product (British Columbia Salmon Farmers Association (BCSFA) 1999).

B.C.'s salmon farming industry has grown rapidly since 1984, and is now the world's fourth largest farmed salmon producer, representing four percent of total world farmed salmon production (BCSFA 1999). Much of this growth has been fuelled by consumer demand for more healthy and convenient foods.

Despite the substantial contribution to the provincial economy, several key issues have been identified surrounding the existence and management of salmon farming including potential impacts of escaped farmed fish, effects on fish health, waste discharge concerns, interactions with marine mammals and other species, and siting concerns.

In 1995, public concerns over the lack of regulation of salmon farming led to an official moratorium on approval of new sites, and the initiation of the Salmon Aquaculture Review (SAR). After adopting some of the recommendations set forth in SAR, the provincial government planned to award five fish farm licenses in August 2000, with the objective of

pioneering new fish farming techniques. However, a series of escapes, particularly an incident involving the loss of 32,000 Atlantic salmon in Johnstone Strait off northeastern Vancouver Island, caused the government to cancel the awarding of these licenses. Following this event, in October 2000, the government released new regulations aimed at preventing escapes. These regulations have been touted as the most comprehensive in the world. Despite such initiatives, consensus among regulators, industry, and the public on the conduct of the industry remains elusive.

1.2 *Purpose and Objectives*

The purpose of this paper is to evaluate the existing and proposed strategies for managing the salmon aquaculture industry in B.C. The objectives are to:

- identify and evaluate strategies that have been employed for managing the industry in B.C.
- identify and evaluate strategies that have been employed for managing the industry in other jurisdictions, and
- conduct a comparative analysis and make recommendations for strategies which may encourage sustainable management of the salmon aquaculture industry in B.C. and identify areas of potential comparative advantage for the province.

1.3 *Methods*

A variety of methods were employed to conduct this study. In order to provide a context for an assessment of management practices, the history of salmon aquaculture and emerging environmental and socioeconomic issues in B.C. were examined based on a review of existing literature. Next, existing and proposed management strategies in B.C. were evaluated using relevant literature, as well as through discussions with representatives of government, industry, and environmental groups. Following this, existing and proposed management strategies in other jurisdictions were evaluated by reviewing relevant literature and current legislation. Finally, a comparative analysis and recommendations for changes to management practices in B.C. were developed through an overall analysis of the advantages and disadvantages of current practices in B.C. and elsewhere.

1.4 Report Organization

This paper is organized into four chapters. Chapter 1 provides a background and rationale for conducting the study, the purpose and objectives for the paper, and the methods used to achieve those objectives. The history of salmon farming in B.C. is outlined in Chapter 2. It also identifies and examines environmental issues, as well as the management practices that have resulted in controversy and conflict. Chapter 3 explores and assesses management practices, including legislation used to regulate salmon aquaculture in four jurisdictions outside of B.C. An evaluative matrix is provided in Chapter 4 to compare these management practices with those in B.C. A comparative analysis of the range of management options that have been proposed, or are in practice, in B.C. and elsewhere are also examined, to ascertain which would be best suited for the salmon farming industry in B.C. This chapter also provides recommendations aimed at reducing environmental perturbations and the ongoing atmosphere of confrontation.

Chapter 2 HISTORY OF SALMON FARMING

2.1 Global Background

Over the past decade, global aquaculture output has risen at a rate of 11 percent a year, representing the fastest growing sector of the world food economy. In 1990, 13 million tons of fish were produced; by 1998 this amount increased to 31 million tons (Brown 2000). With this rate of increase, it is predicted that fish farming may soon overtake cattle ranching as a food source. While both beef production and oceanic fish catch have risen substantially over the past century, since 1990 there has been little growth in either sector as exploitation levels have reached, and in some cases exceeded, natural sustainable production capacities. Therefore, in order to satisfy increasing demand for animal protein, alternatives have been explored. Because the efficiency with which fish convert grain into protein is generally much greater than that of cattle, aquaculture is a preferred option, particularly in developing countries that account for 85 percent of the world's aquacultural output. In 1998, the total worldwide aquacultural output was 31 million tons, of which China produced 21 million tons, followed by India with 2 million tons (Brown 2000). Other developing countries involved in aquaculture production include Bangladesh, Indonesia, and Thailand. Japan, the United States, and Norway lead in aquaculture production in industrial countries, primarily focusing on high-value species, one of which is salmon. The trend towards salmon aquaculture in industrial countries is noteworthy because food conversion efficiencies in carnivores, such as salmon, are low compared with herbivorous species such as carp and catfish. For example, salmon are fed a diet consisting primarily of fishmeal, and require up to five tons of landed fish for each ton of salmon produced, which may intensify pressure on oceanic production.

Worldwide, farmed salmon production reached almost 1.1 million metric tons in 2000. A summary of the world farmed salmon production by major producers over the past five years is outlined in Table 1.

Table 1
World Farmed Salmon Production by Major Producers (in metric tons)

Producer	1996	1997	1998	1999	2000
Australia	7,500	8,000	7,200	10,000	12,000
Canada (B.C.)	24,913	32,514	39,255	51,368	51,368
Canada (New Brunswick)	15,500	17,700	-	-	27,400
Chile	135,300	188,900	167,490	222,900	297,900
Faroe Islands	-	-	18,200	39,150	41,649
Iceland	-	5,280	3,800	4,250	4,000
Ireland	11,500	13,500	12,580	18,286	20,560
New Zealand	6,300	6,000	5,900	5,700	
Norway	280,600	342,000	390,000	462,000	515,000
England	74,700	83,300	104,500	119,000	127,000
United States	5,000	4,860	-	-	-
Total	**561,313**	**702,054**	**748,925**	**932,654**	**1,096,877**

Note: "-" numbers are unknown

Source: Atkinson (2000)

Norway consistently leads the world in the production of farmed salmon, followed by Chile, and England (including Scotland). All of these countries experienced dramatic increases in salmon production over the past five years. In Canada, production has nearly doubled in the same time period, with B.C. ranking fourth in world production.

While salmon farming originally began in Canada in the 1970's, it was not until the 1980's that it expanded into a viable industry. In Atlantic Canada, most salmon farming is in New Brunswick, and to a lesser extent, in Nova Scotia. It was with Norwegian money and expertise that the industry gained momentum in New Brunswick. Canadian federal and provincial government grants, interest-free loans, and loan guarantees in the amount of $34 million between 1985 and 1996 also fueled expansion of the industry (Weber 1998).

2.2 *Background of Salmon Farming in British Columbia*

British Columbia has 16,000 miles of coastline and inlets, high levels of tidal flushing, and a moderate climate. These factors give this province greater potential for salmon aquaculture production than Atlantic Canada. Salmon in B.C. are grown in marine cages along the coast of B.C., extending from the Strait of Georgia to Bella Bella, including waters between Vancouver Island and the mainland, as well as along the west coast of Vancouver Island. In this area, 121 tenures currently exist, with over 85 operational farms, each having between 10 and 30 net cages or pens. These farms are supported by 11 hatcheries and two freshwater lake pen-rearing areas for smolts (Alverson and Ruggerone 1998).

Initially, salmon farming in B.C. consisted of coho and chinook salmon, mostly because they are indigenous and broodstock was locally available through government operated hatcheries. Atlantic salmon has largely replaced these species as they have a competitive advantage over coho and chinook because they reach market size quicker and can be sold at a higher price. Originally, the federal Department of Fisheries and Oceans (DFO) opposed the importation of Atlantic salmon because of concerns over disease transmission and displacement of native stocks. Despite these concerns, DFO reversed its initial decision in 1985 and permitted Atlantic salmon importation.

From 1984 to 1988 the salmon farming industry experienced substantial expansion, growing from ten to 150 sites. Government research and financial support helped fuel this growth. Production increased from 107 tonnes in 1984 to 22,000 tonnes in 1995, worth $165 million. In comparison, the commercial salmon fisheries landed $82.5 million of salmon in 1995 (Weber 1998). Despite the moratorium on new sites, by 1999 production had grown substantially, with B.C. producing 46,738 tonnes of farmed salmon valued at $347 million. More than three-quarters of production in 1999 was Atlantic salmon (BCSFA 1999). In part, the increase in production is due to improvements in feed as well as decreased mortality rates. It could be expected that without this moratorium, the growth in salmon farming production in B.C. over this period would have been even more dramatic.

Originally, the market for B.C. salmon was primarily Vancouver and Seattle. However, B.C. salmon aquaculture companies found it difficult to compete against the flood of farmed Norwegian salmon on the world market, resulting in the demise of one third of these companies between 1988 and 1990. A recent analysis indicated that the top six B.C. salmon aquaculture operations are subsidiaries of multinational corporations (Weber 1998).

2.3 *Environmental Issues*

Despite the substantial economic contribution to the province, there has been considerable controversy surrounding the existence and management of salmon farms in B.C. and the potential detrimental environmental effects of salmon farming. The following are the main issues confronting salmon farming in this province and elsewhere.

2.3.1 Impacts of escaped farmed salmon on wild stocks

In the late 1980's, salmon farmers shifted the composition of their salmon species from primarily Pacific to primarily Atlantic salmon. This caused considerable concern among some groups over possible negative side effects of escaped Atlantic salmon on native species. For example, concerns were raised that farmed salmon may out-compete wild salmon for food and resources because farmed salmon are often faster and more voracious feeders. In addition, possible interactions between farmed and wild salmon may increase the risk of the introduction and spread of diseases in wild stocks. Furthermore, not only is there a chance of interbreeding between farmed and wild salmon, but also farmed salmon may have a breeding advantage over wild salmon and could eventually displace wild populations.

In a submission to the Salmon Aquaculture Review by the B.C. Salmon Farmers Association in 1996, the salmon farmers expressed the view that farmed salmon rarely escape and there is no evidence Atlantic salmon pose a threat to native species by increased competition with wild fish for space and food, or that they are a significant predatory threat. They also expressed the opinion that there is only a remote chance "to the point of being negligible" that damage to wild species due to genetic effects will occur (BCSFA 1996).

Based on these conclusions, BCSFA members felt there was no justification for further stalling progress of the salmon farming industry or for applying precautionary standards to the industry that were more restrictive than those applied to other industries. They also felt, however, that,

"...this does not mean that further precautions cannot be taken or that the industry is unwilling to take any steps it can to make an apparently harmless situation even more harmless."

This view was in contrast to the Food and Agriculture Organization of the United Nations who adopted the "precautionary principle" in 1995 in relation to both wild fish and aquaculture management:

> Because of the high probability of irreversibility and unpredicted impacts many species introductions are not precautionary. Therefore, a strict precautionary approach would not permit deliberate introductions . . . in relation to aquaculture, experience has shown that animals usually escape the confines of a facility. As a consequence, the introduction of aquatic organisms for aquaculture should be considered as a purposeful introduction into the wild (Ellis 1996).

2.3.2 Fish Health

Salmon farming has been attributed with the introduction and spread of diseases and parasites that potentially affect wild salmon stocks. To address this risk, the B.C. salmon farming industry has followed standard agricultural disease prevention practices and the relevant practices outlined in Norway's *Interim Fish Diseases Act*. In addition, the industry adopted a zero tolerance for viruses in its broodstock screening. Some literature indicates that disease transmission is more likely from wild stocks to farmed fish than vice versa, and therefore, indigenous disease is a more significant threat than exotic disease to the B.C. salmon farming industry (BCSFA 1996).

Disease outbreaks in net cage operations are primarily due to the crowding and associated stress on salmon, allowing for easier disease transmission. To combat this, salmon farmers routinely use antibiotics, which have resulted, in some cases, to antibiotic resistance among farmed fish and a perpetuation of the disease problem. For example, a salmon farm in the Broughton Archipelago introduced salmon smolts infected with a strain of *furunculosis* that was resistant to all B.C. approved antibiotics. Wild Chinook salmon in the area became infected, resulting in a collapse of Chinook stocks in an adjacent inlet the following year (Morton 1996). Eventually, the fish farms in the area were permitted to use erythromycin to treat the *furunculosis* outbreak even though erythromycin is not permitted for human consumption or to be discharged directly into the environment.

One study found that 74-100 percent of wild fish caught near fish farms contained antibiotics in their flesh, some with levels above acceptable levels for human consumption (Yousif et al. 1994). Another report indicated that the accumulation of antibiotics beneath fish farms has reached 400 and 500 parts-per-million in sea water (Morton 1996).

A further issue regarding fish health is the use of pesticides in farmed fish to control parasites, primarily sea lice. Concerns have been raised regarding dangers induced by the use of pesticides. These relate to their potential for accumulation in the environment, adverse effects on aquatic life, and risk of ingestion by humans of aquatic species that have been affected by pesticide use.

2.3.3 Waste Discharge

It is common for excess food and fish faeces to accumulate beneath and adjacent to salmon net cages. Accumulations of waste can lead to the production of toxic hydrogen sulphide, methane gases, and the smothering of benthic habitat. The areal extent and degree to which the seabed is affected is dependent on tidal current strength and direction.

As salmon are extremely sensitive to environmental conditions, it is in the best interest of the salmon farming industry to continually assess and attempt to improve the conditions in and around their net pens. Nutrient levels in the water surrounding salmon farms in Puget Sound have been monitored for a number of years. Based on these results BCSFA members are of the view that waste discharges can be managed to within acceptable environmental limits (BCSFA 1996). The salmon farmers believe that this can be accomplished through the use of realistically achievable performance standards and the establishment of future salmon farm sites in areas where there will be minimal or short-duration environmental effects from waste discharge.

First Nations in the Broughton Archipelago are concerned with the absorption of antibiotic residues from feed and faeces by marine life, particularly filter feeding shellfish, such as clams. While one of the more persistent antibiotics, oxytetracycline, is not measurable in the water column after 30 days, there have been few scientific studies that have determined the impact, if any, of antibiotics on marine biota, either short or long term.

2.3.4 Interactions with Marine Mammals and other Species

Marine mammals, such as harbor seals, sea lions, and river otters, are attracted to fish farms due to the high concentration of salmon. These predators often tear open net cages resulting in salmon escapes. Not only do these escapes cause concerns such as those mentioned above, but the loss to the salmon farming industry in economic terms can be substantial. For example, it has been estimated that the direct and indirect loss to the salmon farming industry due to predation from these animals approximates $10 million per year (BCSFA 1996). Additional losses may be caused by predation from mink and birds.

A variety of methods have been employed by the salmon farming industry to deal with predators including dogs, predator nets, electric fences, acoustic deterrent devices, seal bombs, guns, and traps. The most controversial method employed to deter predators is the shooting of seals and sea lions when they approach salmon net cages. It is possible to obtain a permit from DFO to legally destroy harbor seals and sea lions, and it is estimated that 500 seals and sea lions were killed annually from 1990 to 1994 (Ellis 1996). While currently there appears to be no danger to the overall population of these marine mammals, many environmental groups and members of the public are opposed to the killing of these mammals.

Another controversial method to deter predators is the use of acoustic deterrent devices because they may deafen seals and sea lions over time. There is also concern that they may interfere with other animal communication signals. For example, harbor porpoises seem to avoid previous traditional habitat where acoustic deterrent devices are used.

In addition to deterrent mechanisms, night lighting of net cages to produce faster growth in salmon, may adversely affect other species. While there have been few scientific studies on the effects of night lighting, it appears that some species, such as herring, may be attracted by the lights and are subsequently consumed by farmed fish. As well, if wild fish are attracted to the light, there is a greater chance of transfer of disease between wild and farmed fish. It has also been argued that night lighting is aesthetically undesirable to local residents and recreational users.

2.3.5 Salmon Farm Siting

There are certain qualities that are considered desirable for salmon farm siting including good marine water quality, accessibility from shore, availability of fresh water, safe moorage, and proximity to population centers. Unfortunately, these same qualities are often desirable for other activities, such as recreational use and marine tourism. Other issues surrounding siting of salmon farms are the local ecological effects discussed above, as well as proximity to migration routes of wild stocks because of the potential for spread of disease from farmed salmon to native species. The State of Alaska considered the risk so dangerous it passed legislation to ensure no salmon farm development occurs along migration routes (Ellis 1996).

Unfortunately, siting policies and procedures that were used to locate fish farms in the early 1980's, when the industry was expanding rapidly, were not effective and did not take into account all interests or the effects on the surrounding environment. Many siting decisions were made without adequate public input and were determined on a site-by-site basis, rather than on an analysis of the potential cumulative impacts on the area.

2.4 Regulatory Framework

Since the middle of the 1980's, the provincial government has reviewed the regulations applicable to the industry several times and has made numerous recommendations for improvement. However, in 1992 the government decided not to approve any new sites because it was determined the regulations were still inefficient and ineffective. This was followed in April 1995 with an official moratorium on approval of new sites. Not surprisingly, the moratorium caused considerable distress among salmon farmers in B.C. who felt their international competitive standing would suffer and that it would be difficult to regain their position if the moratorium was not lifted quickly.

In November 1995, in a further effort to address this controversial issue, the then Ministers of Environment, Lands and Parks (MELP) and Agriculture, Fisheries and Food (MAFF) proposed that the provincial Environmental Assessment Office (EAO) conduct an environmental assessment review of salmon farming in B.C. The purpose of the salmon aquaculture review was to make recommendations regarding management and regulation of salmon farms and to

provide policy advice. In September 1996, EAO commenced SAR, which was completed the following year.

One of the key issues raised with respect to regulation of the industry was jurisdictional responsibility. The federal and provincial governments attempted to deal with the division of responsibilities in 1988 by assigning DFO primary responsibility for ongoing management of aquaculture. However, due to lack of government funds and downsizing in DFO, there were few resources available to effectively manage the industry. As a result, the province took on responsibilities that were presumed to be under federal jurisdiction. To further confuse matters, the provincial government divided its responsibilities over the industry primarily between MELP and MAFF. MELP was delegated responsibility for site approval and MAFF for the granting of licenses and salmon farming policy. Both ministries were given responsibility for supervisory activities. In addition, MELP often referred siting applications to other agencies to determine if there were potential impacts or conflicts. However, MELP was not required to utilize this information and there were no guidelines on how to deal with conflicting opinions (B.C. EAO 1997 (a)).

Salmon farmers were particularly concerned with the lengthy application approval process, which prior to the moratorium was taking up to three years for each application to be granted. Another key issue was the effectiveness of the tenure system. The *B.C. Land Act* (1996) provides that a license of occupation cannot have a term of more than ten years and that the term of a lease is not to exceed 30 years. Salmon farmers were of the view that while the lease option provides a sufficient length of tenure it is too rigid in that it is tied to a specific location and is difficult to obtain. Alternatively, a license of occupation has some flexibility but provides too short a time period to allow for security of tenure.

Once a salmon farm site tenure was approved, MAFF was responsible for regulating salmon aquaculture production and operations through an aquaculture license. Some general terms and conditions required by the license were to:

- comply with an approved aquaculture development plan, which must specify the salmon species to be farmed and maximum permitted production levels

- take reasonable precautions to prevent escapes and promptly report escapes that occur
- ensure that fish are given proper care and attention to meet their biological needs;
- employ reasonable practices to prevent predators and disease
- comply with all laws, bylaws or orders from any government authority which affect the aquaculture facility (Alverson and Ruggerone 1998).

MAFF was responsible for ensuring each aquaculture site was visited once a year to determine whether the holder of the license was violating any of the conditions of the lease. While MAFF could suspend or revoke a license if a violation occurred, this has yet to occur. In addition to DFO, MELP, and MAFF, there are numerous other federal and provincial government departments responsible for regulating the salmon aquaculture industry in B.C. Some of these departments are discussed later in this chapter where applicable.

As was mentioned above, the numerous issues raised concerning the salmon farming industry and lack of an adequate regulatory framework led to the conduct and completion of SAR in 1997. A summary of SAR is outlined below.

2.5 Summary of SAR

The salmon aquaculture review was mandated with examining the key issues surrounding salmon farming in B.C., as well as socioeconomic impacts and alternative technologies. To begin, a series of discussion papers with recommendations on the key issues was undertaken by a technical advisory team (TAT) made up of experts identified by EAO. A review committee was also established consisting of volunteers representing a wide variety of interests to assist TAT in assimilating and disseminating information. This committee held eight workshops in several coastal communities during 1996 and 1997 in order to provide the public with an opportunity to present opinions and submissions for review by TAT. The Broughton Archipelago, off the northeast coast of Vancouver Island where a number of fish farms are located, was chosen as the primary study area to examine the issues. Once the papers were completed, TAT presented its findings to EAO who evaluated the conclusions presented in the papers and prepared the final report for submission to MELP and MAFF.

The general conclusion reached by TAT was that salmon farming, as it was being practiced in B.C. and at current production levels, presents a low overall risk to the environment. However, significant gaps in scientific knowledge were identified. For this reason, it was recommended that the precautionary approach be applied in future management decisions. As part of this approach, it was suggested that preventative management, adaptive management, and performance-based standards be adopted to address this uncertainty. In addition, it was concluded that the salmon farming industry in B.C. is lacking effective regulatory, legislative and policy guidance, and future management decisions should be made based on a more comprehensive public input system, particularly as it relates to siting decisions. Below is a more detailed account of those recommendations outlined in the report that relate to the main issues surrounding the industry.

2.5.1 Impacts of escaped farmed salmon on wild stocks

TAT concluded that it was improbable that colonization of Atlantic salmon in B.C. waters would occur. If this did occur, they determined that it would probably be possible to target and eradicate any stocks that became established. They also determined that the potential for interbreeding between escaped Atlantic salmon and wild salmon was very low, that there was little threat of predation on wild stocks from Atlantic salmon, or that Atlantic salmon would out-compete wild stocks for food. However, they did note that the risk of genetic alteration due to interbreeding between farmed and wild Pacific salmon was a possibility if the number of escapes increases.

In the past, there was little attempt at regulation of farmed salmon escapes outside of a requirement for industry operators to report the escape and obtain a special permit from DFO to recapture escaped fish. However, attempts to capture escaped fish have had limited success. Since 1991, MAFF and DFO have monitored salmon escapes in a program that expanded into the Atlantic Salmon Watch, to determine the presence of Atlantic salmon in the wild.
TAT concluded that currently there is inadequate prevention, monitoring, and reporting of escapes to minimize the risk of escapes and it was suggested that enforceable escape prevention measures should be adopted utilizing best available technology and husbandry practices. As part of this plan, escapes over a certain threshold should trigger review and remedial measures, and

farmers should be required to maintain a computerized tracking system for monitoring escapes. If escapes occur, farmers should develop effective recovery plans for the escaped fish.

It was also suggested that transgenic salmon, or salmon that have been altered by introducing new genetic material into the genetic composition, while not currently raised on salmon farms, should be prohibited due to their potential to out-compete wild salmon for food. As well, research should be conducted on the development of stocks that pose a minimal genetic risk to wild salmon, such as all-female or nonproductive Atlantic salmon.

There are numerous documented cases indicating that escapes of cultured fish occur on a regular basis. The first catches of Atlantic salmon in B.C. waters occurred in 1987, but the first reported to have escaped was a year later in 1988. From 1988 to 1995, 97,799 Atlantic salmon were reported escaped from net pens in B.C. (Ellis 1996). However, this number is not necessarily accurate, as many escapes are not detected. More recently, in August 2000, more than 32,000 Atlantic salmon escaped from a pen in Johnstone Strait off northeastern Vancouver Island. It is estimated that over one million Atlantic and Pacific salmon have escaped from fish farms in B.C. (Judd 2000).

Not only have the number of escapes increased, but the provincial fisheries ministry confirmed that one and two-year old juvenile Atlantic salmon had spawned in the Tsitika River on Vancouver Island, an occurrence that previously was thought to be highly unlikely (David Suzuki Foundation (DSF) 1999).

While it is now apparent that escapes occur, there is still considerable controversy and differing opinions as to what the potential short and long-term impacts escaped fish will have on native stocks. However, a report by DFO's Scientific Review Committee quotes over 40 published expert studies that indicated escaped farmed salmon negatively impact wild stocks. The committee concluded that there has been a reduction of fitness in wild populations in the short term due to interbreeding (DSF 2000 (a)).

2.5.2 Fish Health

In order to protect wild salmon species from risks of infectious diseases and other ecological impacts, several federal and provincial regulations and policies were developed. The federal government regulates the importation of cultured fish or eggs of wild fish into B.C. under the *Canada Fisheries Act* (1985). This regulation requires an import permit that is only issued after imported eggs are determined to have come from a disease-free source or are not considered harmful to the protection or conservation of fish in B.C. Juvenile and adult fish are not permitted to be imported. There are also Atlantic and Pacific salmon import policies, which are aimed at reducing the risk of the spread of infectious diseases. Under the Pacific Salmon Import Policy, egg importation is only permitted for broodstock development programs and there is a maximum annual limit on the number of egg imports. This is not the case under the Atlantic Salmon Import Policy, where there is no limit on Atlantic egg imports (B.C. EAO 1997 (b)). All imported eggs are held in quarantine to determine whether any disease is present. If disease is detected, all stocks at the facility must be destroyed. In a further effort to minimize disease transmission, a federal and provincial transplant committee was formed to issue permits or licenses to transfer farmed fish into, or within, the province.

Despite government efforts to regulate and control disease transmission, there are no extensive regulations that apply to cultured fish, and salmon farmers are only required to notify authorities if specific disease outbreaks occur on their sites. However, it is in the best interest of an operator of a salmon farm to act quickly if a disease or pest outbreak is detected. If an outbreak occurs, the affected fish are usually treated with drugs or pesticides, which are regulated under a number of federal and provincial regulations. Three drugs have been specifically approved for use in salmon aquaculture operations. However, veterinarians are permitted to prescribe "extra label" prescriptions that have not been expressly approved for diseased, farmed salmon. In addition, salmon farmers voluntarily undertake numerous other measures designed to minimize disease outbreaks and transmission. One of these measures is a cooperative assessment of salmonid health, a program run through BCSFA, which tracks fish mortality rates for participating farms and attempts to estimate causes of mortality.

The Canada *Fish Inspection Act* (1985) governs the inspection of farmed fish intended to prevent human exposure to unsafe levels of drugs and pesticides used at salmon farms. DFO officials

conduct random tests to determine the presence of approved antimicrobial compounds, pesticide residues, and heavy metals. Other drugs that may be prescribed as "extra label" by a veterinarian are not necessarily tested. Under the B.C. *Fish Inspection Act* (1996) it is prohibited that anyone may sell fish intended for human consumption that is tainted, decomposed, or unwholesome. As well, it requires a statement that identifies which drugs have been administered accompany fish delivered to a processing plant or buying station.

Concerns over human health have also been raised with respect to harvesting shellfish that are in close proximity to salmon farms due to possible contamination with coliform bacteria from salmon farm sewage. In an effort to address this issue, Environment Canada imposed bans on shellfish harvesting within 125 meters of a salmon farm.
Once again, TAT concluded that there are significant gaps in scientific knowledge regarding the effects of fish farms on fish health. However, they determined that evidence did not support the view that exotic pathogens or parasites have been introduced into B.C. waters and that the probability of exotic disease outbreaks was low. This finding, however, was tempered with the recommendation that government adopt a more proactive approach to disease prevention, coupled with more emphasis on research and monitoring.

TAT also determined that there were inconsistencies and redundancies among the agencies responsible for managing fish health. It recommended an interagency fish health working committee be established to address the many issues surrounding fish health. In addition, it was suggested that a comprehensive surveillance program be developed with public input and carried out by government under legislation. The program should include identification of diseases that require reporting, establishment of enforceable standards for disease prevention, requirements for maintaining health records, outbreak management protocols, and drug use standards.

Although TAT was of the view that the likelihood of disease outbreak from importation of an exotic pathogen in fertilized eggs was low, it felt that the consequences of such an occurrence could be significant. The committee, therefore, determined that government should, for salmonids, continue to prohibit the importation of live fish, unfertilized eggs, and milt, and that a more comprehensive requirement for sampling and reporting of diseases in fish being transferred within the province be adopted.

With respect to the use of pesticides and drugs on farmed salmon, TAT determined that government health agencies should be responsible for determining a management plan to deal with these issues. It also felt government should enhance its monitoring of fish products at processing facilities, particularly to identify whether bacterial patterns are changing. Regarding the risk of contamination of wild fish and shellfish that consume waste feed, which is a concern raised primarily among First Nations, it was suggested that flag indicators be used at farms where drugs are used. In addition, drugs should only be permitted with a veterinarian's prescription.

2.5.3 Waste Discharge

Waste discharge from salmon aquaculture operations are governed by MELP through the B.C. *Waste Management Act* (2000) and the B.C. *Aquaculture Waste Control Regulation* (1988). The *Waste Management Act* requires fish farm operators to obtain permits in order to discharge waste into the environment. As fish mortality is inevitable, waste discharge permit holders must indicate how and where they will dispose of dead fish. However, if certain requirements are met, it may be possible to obtain an exemption from obtaining a permit. In addition, all fish farms must monitor water quality at an intensity based upon the level of farm production. MELP developed an environmental monitoring program for marine fish farms in 1988, which outlined monitoring requirements. However, it was determined that this program was not effective in that salmon farms and MELP were not meeting program obligations and that a new monitoring program was required (B.C. EAO 1997 (a)).

TAT concluded that the above regulations have not proven effective in offsetting negative impacts on benthic communities. Therefore, it recommended that government regulations be established through a performance-based management program that incorporates adequate standards, a requirement for fish farm operators to develop enforceable waste management plans, and establishment of annual fees based on the amount and type of waste discharged by individual fish farms. Farmers should also be required to monitor the effects of waste while MELP be responsible for assessing the data as well as ensuring standards are consistently met. In areas where it is determined a fish farm is having an adverse impact on benthic life, MELP should aid farmers in developing plans to reduce impacts or relocate farms where necessary.

It was also determined that in areas where shellfish beds may be affected by waste discharge, government should develop a program to assess impacts, particularly siting of fish farms in relation to distance from shellfish beds. If it is determined the impacts are significant, alternatives such as relocation of certain farms should be considered.

2.5.4 Interactions with Marine Mammals and other Species

Federal and provincial legislation governs the methods that may be used by salmon farmers to offset the impact of predation on farmed salmon by marine mammals and birds. The federal *Fisheries Act* prohibits anyone from disturbing a marine mammal except when fishing under the authority of these regulations. In particular, while seals and sea lions are protected under the *Act*, it is possible for salmon farmers to obtain a conditional license to kill these marine mammals. Most salmon farm operators have obtained licenses but the licensing system is not actively audited. Similar federal and provincial regulations exist for the capture or killing of birds and small mammals.

After reviewing relevant literature on shooting of predators located near fish farms, TAT concluded that enforceable predator control plans aimed at prevention should be included in aquaculture licenses and that killing predators should only be permitted if they are inside nets and are actively killing fish. If particular farms continue to have persistent problems related to predators, the farm operators should contact government conservation or fisheries officers who may, if they determine necessary, trap and kill certain predators.

TAT concluded that since acoustic deterrent devices are relatively ineffective and pose a significant ecological impact, they should be phased out over a two-year period. They also felt that no new authorizations for night lighting should be issued until further scientific research has been conducted to determine the overall impact night lighting may have on other species.

2.5.5 Salmon farm siting

In order to establish what constitutes a suitable salmon farm location it is important to consider all relevant environmental, social, and economic issues. The identification of salmon farm sites without considering other coastal management issues could lead to inappropriate siting decisions.

Historically, MELP referred applications for siting to other agencies to identify potential impacts and conflicts. However, TAT determined that this system is often ineffective in that there is often conflicting opinions among differing agencies and there is no obligation for MELP to act on comments received. To address this issue an informal Vancouver Island fish farm review committee was established to encourage greater cooperation and consensus among groups. TAT felt this type of approach should be formalized and that an interagency management committee should be instituted to address disagreements among agencies.

In the past, siting decisions were usually made on a site-by-site basis not taking into account cumulative impacts of multiple sites in an area. TAT concluded that integrated coastal management plans should be developed at both the subregional and local level based on consensus among stakeholder groups. As part of these plans, in-depth inventories and mapping should be utilized. There are currently a number of maps that could be utilized as a starting point to achieve the overall objective. For example, B.C. Lands completed a series of opportunity maps based on public input, which identify potential resource or user conflicts. These maps designate three zones: conditional, limited, and no opportunity or high conflict zones. However, adherence to these maps is not yet required and they have not been effective in leading to the prohibition of salmon farms in no opportunity zones. In addition, MAFF has maps and models that identify biophysical fish farm capabilities. Other zoning initiatives include the central coast land and resource management process (LRMP) and the Queen Charlotte Islands (Haida Gwaii) LRMP from which additional maps have been, and continue to be, generated.

2.5.6 Environmental impact assessment

Salmon farm operators are not required to obtain a project approval certificate under the B.C. *Environmental Assessment Act* (1996)(EAA) and there have been no other requirements for salmon farm operations to formally conduct an environmental impact assessment. This was one of the issues that SAR was mandated to review.

TAT concluded that environmental assessments under EAA for salmon farm operations should not be required. They felt that:

> . . . strategic level issues regarding resource use could be dealt with through coastal land use planning or the development of regional or local plans. The recommendations to improve existing decision-making processes indicate that the existing approval processes

> can address many of the issues relevant to assessment of salmon farms if amended as recommended. The recommendations incorporate many aspects of the process used to conduct environmental assessment under the *Act*, including well-developed applications, public notice of applications and distribution of information (through open houses and the local advisory working committees), committee-based assessment of applications and concurrent consideration of approvals (B.C. EAO 1997 (a)).

However, there is the potential under the *Canadian Environmental Assessment Act* (1992)(CEAA) for environmental assessment to be required if a regulatory duty by any federal department is triggered. For example, if a permit under the Canada *Navigable Waters Protection Act* (1985) is necessary or if an authorization under the fish habitat provisions of the *Fisheries Act* is requested, a federal environmental assessment may be required.

2.5.7 Conclusion

There were various responses to the conclusions reached by TAT in the Salmon Aquaculture Review. Proponents felt that as TAT determined the overall risk from salmon farming was low, the moratorium should be lifted and expansion of the industry should be permitted. Opponents felt the opposite. They were of the view that until further scientific research was conducted, the industry should not be permitted to expand. Therefore, while a substantial amount of time and money was spent on SAR, the debate continues.

2.6 Other Initiatives

There are a number of initiatives that have been undertaken since SAR. Joint initiatives among government, industry, First Nations, and environmental groups undertaken since SAR are summarized next by lead agency.

2.6.1 International

In 1998, Canada participated in and supported an international plan, the *International Atlantic Salmon Accord*, which was created and launched through the North Atlantic Salmon Conservation Organization (NASCO) in Scotland. The *Accord* is aimed at saving Atlantic salmon through the involvement and support of more than 30 conservation organizations, representing 11,000,000 million people throughout the North Atlantic. In Canada, the *Accord* is supported by the Atlantic Salmon Federation, regional councils and national affiliates representing 500,000 members. One of the major issues outlined in the *Accord* is the impact of

aquaculture and its affect on salmon during its lifecycle. Some key factors identified for addressing the negative impacts of aquaculture on wild salmon stocks are technological improvements to prevent effluent, infection, and escapes; involving the aquaculture industry in developing solutions; and development of a practical step-by-step process to make the transition to environmentally sustainable and acceptable practices (NASCO 2000).

Building partnerships with the North Atlantic salmon farming industry (NASFI) was one of the issues identified by NASCO. In June 2000, at the seventeenth annual meeting of NASCO, the Canadian Aquaculture Industry Alliance (CAIA) applauded NASCO's efforts in this regard. A NASCO and NASFI liason group was established and their first goal was to identify a working group to develop guidelines on containment to apply to the North Atlantic area covered by the NASCO convention. These guidelines were presented at the June meeting and will continue to be developed over time. While it remains to be seen whether the Accord will have a positive impact on future aquaculture development, it represents an international recognition and effort to offset some of the negative impacts of salmon farming on wild salmon stocks.

2.6.2 Federal government

In 1994, the Liberal Party's election platform took a proaquaculture perspective highlighting improved support and fostering rapid growth of the industry. In 1995, a federal aquaculture development strategy was created to recognize aquaculture development as a priority of the federal government, and to direct federal initiatives towards creating a regulatory and policy framework conducive to industry development. This strategy outlines a cooperative management framework to identify and resolve constraints and challenges to the industry. While DFO is the lead federal agency in implementing the strategy, committees made up of industry and government have been created. These committees have representation from industry associations, academia, and all relevant federal, provincial, and territorial agencies and departments with a role to identify developmental problems and to determine the expertise, technology, and resources required to implement solutions.

As part of this strategy, in January 1999, David Anderson, the then Canadian minister of DFO, announced the appointment of a commissioner for aquaculture development. The commissioner is the leader, on behalf of the federal government, for developing the aquaculture industry in

Canada, and reports directly to the minister. The role of the commissioner is to help better focus the federal government's aquaculture development strategies and to work collaboratively to ensure the programs meet industry needs. The goals of the office of the commissioner for aquaculture development are to review the legal framework governing aquaculture in Canada, make Canadians aware of the positive benefits of aquaculture, and work towards better integration of aquaculture with other users of the oceans and waters of Canada. As part of this development strategy, in June 1999, the commissioner announced that he would be conducting a comprehensive review of the laws and regulations that affect the aquaculture industry in conjunction with consultation with all levels of government. This decision was based on the industry view that certain regulations are not effective or are superfluous, particularly given that there are seventeen federal departments and agencies responsible for regulating the aquaculture industry. The review will also evaluate controls now in place, or that should be in place, to protect the environment.

In addition to the development strategy, in October 1999, the commissioner announced a new aquaculture partnership program. The program is aimed at helping the aquaculture industry develop partnerships and work together on projects of national or regional significance. Projects must meet the goals of the office and the minister will approve all projects based on the advice of the commissioner. The commissioner has approved funding of $600,000 per year for a period of three years. Eight project proposals were received during the first quarter of the program and four of these were approved in April 2000. Of those approved, the BCSFA received $134,600 to develop a coordinated fish health management program for fish culture facilities in B.C. In 2001, a further $90,402 was issued to two aquaculture projects, one of which was a colloquium on sea-farming held in Quebec (Canada 1999).

Further to this funding, Herb Dhaliwal, the minister of the Department of Fisheries and Oceans, announced a program in August 2000 for sustainable aquaculture. Under this program, the federal government will invest $75 million over five years for the sustainable development of aquaculture. The program is aimed at providing industry and government with funding to conduct research and development, strengthen measures to protect human health through an enhanced shellfish water quality monitoring program, and implement a legislative and regulatory framework for the industry (SeaWeb Aquaculture Clearinghouse 2000 (a)).

Despite these efforts by the federal government to better manage the salmon aquaculture industry, a critical report from the federal auditor general's office on *The Effects of Salmon Farming in B.C. on the Management of Wild Salmon Stocks* was released in February 2001. While DFO is legislatively responsible for protecting wild salmon, it is managing the industry on the basis outlined in SAR that it poses an overall low risk to wild salmon and habitat. However, the report determined that the department does not have sufficient scientific information to ensure compliance monitoring and enforcement activities are protecting wild salmon and their habitat and DFO is therefore unable to enforce the provisions of the *Fisheries Act*. The report also suggested that DFO has not made sufficient progress in identifying areas and priorities for research in order to assess whether or not the industry should be permitted to expand. While the department is reviewing the federal regulatory framework, the report indicated that a precautionary approach should be incorporated into its decision making process. Finally, the report stated the conclusion that "Fisheries and Oceans is not fully meeting its legislative obligations under the *Fisheries Act* while participating in the regulation of salmon farming in B.C."

2.6.3 Provincial initiatives

Following SAR, the provincial government agreed to implement all 49 regulatory and operational recommendations, however, many of them have yet to be put in place. In addition, in October 1999, MELP announced the creation of a new provincial government salmon aquaculture policy. The policy is aimed at establishing more stringent environmental standards while at the same time attempting to provide greater certainty to the salmon farming industry. The key components of the policy include escape prevention, a move towards performance-based environmental regulation of salmon farm wastes, relocation of inappropriately located sites and stricter siting criteria for relocated sites, improved fish health, and the development of alternative salmon farm technology pilot projects.

To aid in the implementation of the policy, a deputy ministers' salmon aquaculture steering committee was established. On a more technical level, project coordinators were identified in BC Assets and Lands, BC Fisheries, MELP, and DFO to coordinate implementation within and among government agencies. In addition, a fish farm review committee with representatives

from numerous ministries and DFO was formed to provide advice on relocation of inappropriately sited farms. In order to give stakeholders an opportunity to provide advice on implementation issues, a salmon aquaculture implementation advisory committee was also established.

The policy established a two-year period over which government, industry, communities, and First Nations will attempt to resolve outstanding issues as well as ensure industry incorporates more environmentally sustainable management practices. At the completion of the two-year time, the future direction of salmon farming in B.C. will be evaluated.

To date, numerous efforts have been made to address the key components of the policy. Following two escape incidents in August 2000, one involving the break out of more than 32,000 Atlantic salmon from a pen in Johnstone Strait off northeastern Vancouver Island, BC Fisheries Minister Corky Evans announced a new regulatory regime requiring fish farm companies to provide government with escape-prevention plans by October 2000. The plans were required to meet new standards and practice for operations and equipment as well as include mandatory monitoring and staff training. The standards include practices associated with transporting fish, maintenance of stock records, escape notification, preparation of response plans, and routine net inspection. All active aquaculture sites have now submitted these plans to comply with these regulations. In addition, in October 2000, the provincial government announced new fish farm escape regulations that they consider are the most comprehensive in the world. In the past, the regulations stated that fish farms were supposed to act with "due diligence" with respect to escapes, but it was determined this language was not specific enough. Therefore, the new regulations are more specific in that there must be compliance with a number of standards of practice and that "a person must not cause, authorize, or allow the escape of fin fish from a containment structure" (B.C. *Fisheries Act* 2000). If an escape is detected, it must be reported within twenty-four hours of the discovery and must include numerous details regarding the escape. While the regulations are now more specific, the penalties for noncompliance have not changed. The legislation still allows the government to cancel or revoke a fish farm license and fines can go up to $2,000 a day. While fines have been implemented in the past, there has never been a case where a license has been revoked.

In an effort to address the issue of salmon farm wastes, the industry has undertaken sampling in the vicinity of all active farms. Focused studies have also been implemented on six farms to provide information on the relationship between waste deposits and the effect on benthic communities. Government has also conducted sampling of sediments at 32 farms. The results of these studies will be used to develop performance-based standards that are expected to be established by October 2001.

With respect to relocations and new siting criteria, a number of farms have been identified as candidates for relocation, based on social, environmental, and economic selection criteria. Some of these sites have been relocated and others will be moved once appropriate new sites are identified. In one case, a fish farm near Quadra Island that was experiencing waste management problems due to poor tidal flushing, was moved to a more suitable site on the Central Coast. The site was moved following an environmental review undertaken through an interagency process led by the B.C. Assets and Land Corp. and B.C. Fisheries with input from MELP, DFO, and the public (SeaWeb Aquaculture Clearinghouse 2000 (b)). The new tenure and aquaculture license was based on a cooperative partnership between Nutreco and the Kitasoo First Nation.

In addition, a finfish aquaculture management plan, which contains the primary regulations and requirements to regulate the industry, has been revised based on input from regulatory agencies including DFO, Coast Guard, BC Fisheries, MELP, and B.C. Assets and Lands (B.C. Fisheries 2001). The major changes adopted relate to more detailed escape response and reporting requirements.

To oversee and coordinate interagency and intergovernmental fish health initiatives, B.C. Fisheries established a fish health working committee. One of the initiatives includes a new fish health code of practice that is currently being developed. In addition, a pilot fish health database is being advanced to improve fish-health information. To verify information provided through the fish health database, a B.C. Fisheries disease surveillance and auditing program has also been established. The program includes active, on farm sampling to verify causes of mortality.

As fish farming operations in B.C. and Washington State are interrelated, the provincial government has been meeting with representatives from Washington to discuss possibilities for

implementing a loss prevention protocol. This protocol is expected to be completed soon (Canada NewsWire 2000).

The provincial government has also created an aquaculture research and development trust fund and the Open Learning Agency and North Island College have begun developing programs to train future aquaculture students.

2.6.4 Industry initiatives

Salmon farmers in B.C. recognize that the existence of their industry is in jeopardy and that they may be forced out of business through a variety of commercial and environmental regulations. They realize that proactive measures are required within the industry to offset some of the negative environmental impacts and public opinion.

Therefore, the B.C. Salmon Farmers Association has been involved in many joint initiatives with both provincial and federal governments as well as First Nations and environmental groups to ensure the future viability of their industry. In January 2000 the industry voluntarily released a code of practice (the code) aimed at protecting the "safety and well-being of our employees, the natural environment, and our salmon stocks" (BCSFA 2000(a)). The code contains standards that are based on existing aquaculture regulations; standard practices, which all members are required to implement on all farm sites; and best practices, which members are encouraged to implement. Both the standard practices and the best practices are attempts to move beyond existing legislation. A BCSFA compliance committee was established in January 2001 to receive and investigate complaints related to noncompliance of the code and to make recommendations to the BCSFA board of directors about corrective actions or penalties for noncompliance. The code consists of two sections, one dealing with the natural environment, the other with husbandry. The section on the natural environment outlines procedures for training, waste material, stock escape, fish mortalities, and blood water disposition, predator control, and site appearance. The section on husbandry outlines procedures for routine fish health checks, stock, equipment, stocking densities, feeding, fish health, therapeutants, stock management, site separation, and use of fallowing.

In addition to the code, the industry has made attempts to encourage salmon farmers to enhance their operations through the use of aquaculture awards that honor achievement, innovation, and

environmental initiatives. The first awards were presented in January 2000. One award for aquaculture business of the year was given to a company that was significantly involved in developing the code and in making efforts to build bridges with First Nations groups. Another award for environmental initiative was presented to a company that developed protocols for environmental monitoring of farm sites and was one of the first companies in B.C. to be granted certification in ISO 14000 audit procedures for salmon aquaculture.

The industry has acknowledged that destruction of wildlife is not acceptable to the general population of British Columbians. Therefore, in May 2000, BCSFA, together with federal and provincial government officials and fisheries stakeholders, announced the formation of a special task force to identify nonlethal solutions to deal with conflicts with marine predators. BCSFA recognizes that the solutions will probably require substantial investments on the part of salmon farm operators and could include heavier gauge nets, semirigid pens, and other specialized predator control equipment. While alternatives are being explored, BCSFA has indicated that destroying of sea lions or other predators will only be used as a last resort if they threaten human safety, threaten to cause significant escapes, or cause extraordinary losses to farm stocks. Some salmon farmers on the west coast of Vancouver Island have voluntarily removed firearms from their farms sites and have agreed to call upon animal control experts if they experience persistent predator problems. This decision was made in part because of the recent designation of Clayoquot Sound as a United Nations biosphere reserve.

In October 2000, BCSFA announced a $9.7 million industry investment to help develop "green" technologies. This investment was related to a decision that was made by the B.C. environment minister and fisheries minister to approve four aquaculture pilot projects. These projects are designed to apply and test innovative aquaculture technologies and husbandry practices, including closed containment systems, alternative feed sources, waste recovery systems, and 100% female farm stocks. Two B.C. First Nations were among the successful proponents. It is projected the sites will generate gross revenues of $88.1 million over the next five years (BCSFA 2000(b)).

At the NASCO meeting in June 2000, issues related to the use of transgenic fish were discussed, primarily because of growing public concern about the use of genetically modified fish. While

transgenic fish are not permitted in aquaculture production anywhere in the world, CAIA does not support the use of transgenic fish "until they can be shown to be safe for the consumers and the environment" (BCSFA 2000(c)).

2.6.5 The David Suzuki Foundation

While there are a number of environmental groups and organizations that have numerous initiatives aimed at prohibiting or amending salmon aquaculture practices in B.C., many of the arguments are similar. Therefore, for the purposes of this paper, only the views and initiatives of the David Suzuki Foundation are presented.

While DSF does not oppose aquaculture in general, DSFs members believe that the way salmon aquaculture is currently being practiced in B.C. presents serious threats to wild Pacific salmon, the wider marine environment, and human health. In particular, DSF is against the use of open net cages because of the risks posed by escaped farm salmon interbreeding with wild Atlantic and Pacific salmon stocks, the risks posed by the introduction and spread of infectious diseases, and the ecological impacts of escaped farm fish (DSF 2001(a)).

Since SAR, DSF, along with other environmental, fishing, tourism, and recreation organizations, as well as many First Nations, formed an alliance against net cage aquaculture calling for the conversion to closed containment systems. In response to the new fish farm regulations that were announced in October 2000 regarding fish farm escapes, Dr. Suzuki stated: "these are the kind of amendments . . . which I find pathetic" (DSF 2000 (b)). In particular, he felt that even the best human intentions would not stop net cages from being ripped apart in storms and allowing escapes to occur.

In addition to replacing open net cages with closed-loop containment systems, DSF also recommends the following policy changes:

- use native salmon only; prohibit use of exotic species
- eliminate discharge of fish sewage (zero discharge)
- protect public health by fully and openly monitoring drug use and the spread of drug-resistant diseases

- require industry-funded government testing for diseases among farmed and wild fish
- require operators to be insured for the full ecological restoration costs of disease epidemics, escapes, genetic pollution, and other catastrophic events
- require industry to develop and fund site reclamation plans
- introduce a royalty or resource-use rent for salmon farmers
- limit industry access to public subsidies, which must be audited and made public
- implement a process to gain agreement of coastal communities and First Nations regarding the location of all existing or proposed aquaculture operations
- prohibit the use of firearms and acoustic deterrent devices to harass marine mammals, and require the use of technologies that safely separate local wildlife from salmon farming operations
- eliminate the use of fish that could be used for human food as the primary feed for farmed salmon (DSF 2001(b)).

Most recently, DSF commissioned a study on the salmon farming industry that was subsequently televised on February 14, 2001 by the Canadian Broadcasting Corporation on *The Nature of Things* called "The Price of Salmon". The documentary was filmed in Norway, Scotland, and Canada and examined a broad range of environmental issues surrounding the salmon farming industry. In particular, the documentary claimed that farmed salmon contain higher levels of PCBs, dioxins, and other persistent organic pollutants (or POPS) than wild salmon, and may pose a human health risk.

The broadcast was not well received by the salmon farming industry, and CAIA president Anne McMullin refuted the documentary's arguments claiming they were not based on science (McMullin 2001). She claims there are no published studies anywhere in the world that indicate farmed salmon have higher levels of PCBs, dioxins, and other compounds than wild salmon. Furthermore, she says the documentary's claims are only based on a sample of eight fish, four wild and four farmed, which is too few to reach any scientifically defensible conclusions.

Chapter 3 OTHER JURISDICTIONS

This chapter will examine the salmon aquaculture industry in four jurisdictions: Norway, Chile, Scotland, and Washington State. The reason for choosing these jurisdictions is because the first three are the world's largest producers of farmed salmon and Washington State because it is geographically similar, and is directly affected by, salmon farming operations in B.C.

3.1 Norway

3.1.1 Background

Norway was a pioneer in the development of the salmon farming industry. This was in part because Norway is situated in an area where there are thousands of miles of coastline, much of it protected, making it ideal for salmon farming. The industry began slowly in this country in the 1960's but then grew rapidly in the 1970's. The Norwegian *Fish Farming Act* (1973) outlined procedures for government to issue salmon farm licenses, which grew from 13 in 1974 to 84 in 1977 (B.C. EAO 1997 (c)). This growth continued into the 1980's and by 1984, 354 licensed farms were producing 29,500 tonnes of salmon worth $108US million. Salmon farming at this time was Norway's second most valuable fishery after cod. By 1985, technological advances enabled farmers to raise 150-200 tonnes of salmon, two-thirds more than they were able to produce in the previous year. These successes led Norwegian salmon farmers to begin exporting technology, equipment, and financing to other countries including Canada, the United States, and Chile. The exponential growth and large profits attracted more farmers to the area and in 1985, 2500 applicants competed for 150 licenses. Production levels continued to increase so that by 1990, 146,000 tonnes of salmon were produced (Weber 1998).

The tremendous growth in salmon production led to a glut on the market so that the price for Norwegian farmed salmon fell from $10.50-11.00US/kg in early 1988 to $8.80US/kg by December of the same year. In 1989, Norwegian farmers exported nearly all the salmon they produced at a value of $500US million and salmon prices fell another 17 percent. In Scotland and Ireland, salmon farmers made allegations that the Norwegians were unloading salmon on the market below cost, which led to an investigation by the European Union (Weber 1998). The result was the establishment of set minimum prices for salmon imports into the European

Community. Despite this setback, salmon farming in Norway continued to expand and they are still the leading salmon farming country, with a production of 515,000 tonnes of salmon in 2000 (Atkinson 2000).

This growth in salmon farming in Norway has not come without its costs, however, and many of the issues that plague salmon farming in B.C. have been experienced in Norway. In particular, high levels of pollution and health problems in fish led to regulatory changes and an increase in research and development. However, many issues remain unresolved.

3.1.2 Regulatory framework

There are four ministries responsible for administering the laws and regulations governing salmon aquaculture in Norway. These are the Ministry of Fisheries, the Ministry of Environment, the Ministry of Agriculture, and the Ministry of Local Government and Labour.

The Ministry of Fisheries is responsible for administering the Norwegian *Act Relating to the Breeding of Fish, Shellfish Etc.* (B.C. EAO 1997 (c)). The purpose of the *Act* is "to contribute towards the balanced and sustainable development of the fish-breeding industry to help it become a profitable and viable industry". In general, the *Act* regulates activities related to fish farming and stipulates licensing conditions. Every fish farm operator must obtain a license and the Ministry of Fisheries has the authority to determine the overall number of licenses to be issued. In particular, the *Act* states that a license will not be issued if there is a risk that the fish farm will cause the spread of disease, increase the risk of pollution, or conflict with other activities in the area. It is the responsibility of the fish farm operator to demonstrate that the above stipulations are met, and that a plan for handling waste is in place prior to obtaining a license or expanding a fish farm. After a license has been issued, it may be revoked if it is determined that a fish farm has caused, or is at risk of causing, the spread of disease, pollution or conflict with other activities. However, if the farm operator mitigates these damages the license may not be withdrawn. The *Act* also provides for regulations requiring all fish farms to maintain a daily log of inspections and maintenance. In particular, a fish farm must be inspected immediately following bad weather.

The Ministry of Environment is responsible for issuing waste discharge permits under the Norwegian *Pollution Control Act.* The Ministry of Agriculture administers the Norwegian *Interim Fish Diseases Act*, which contains regulations for controlling and reporting fish diseases, the use of therapeutants, and the import and export of aquatic organisms. The Ministry of Local Government and Labour regulates siting under the Norwegian *Planning and Building Act* (B.C. EAO 1997 (c)).

3.1.3 Escaped farmed salmon

One of the most contentious issues surrounding salmon farming in Norway is the issue of escaped fish. In order to address this issue, the *Act Relating to the Breeding of Fish, Shellfish, Etc.* contains regulations that require fish farm operators to construct and operate their net pens such that there is no risk that fish will escape. Despite these regulations, it is estimated that half-a-million farmed fish escape each year. In addition, as part of the *Act*, fish farm operators must conduct regular fishing in an area surrounding their net pens to determine whether fish escapes are occurring. If escapes are detected or suspected, the operator must immediately notify the regional director of fisheries. In this event, it is required that a fish farm operator recapture the escaped fish unless this requirement is waived by the director.

3.1.4 Fish health

With respect to fish health, the *Interim Fish Diseases Act* requires that a farm operator notify an official veterinary officer if a disease outbreak is detected. In addition, there is a regulation specifying the maximum density of fish per production unit permitted to prevent stress and consequential disease outbreaks.

Regulations under the *Act* require that therapeutants be prescribed by a veterinarian and that all prescriptions be submitted weekly to the directorate of fisheries by fish farmers, pharmacies, and feed mills. This information is collected and compared to detect unauthorized use of therapeutants. Prior to harvesting, samples of farmed fish treated with drugs in the previous twelve months must be tested for drug residues.

In a further effort to control the spread of disease, the *Act* contains regulations that govern the transport of live-farmed fish within specific geographic areas. In addition, there are provisions that authorize governing the transfer of fish between farms as well as methods of transport.

In 1998, more specific regulations were promulgated to control the spread of sea lice. These regulations were developed because sea lice have been a significant health problem in Norwegian fish farms for many years. The regulations contain minimum measures to reduce the incidence of sea lice and include mandatory counting, recording, and reporting on the incidence of sea lice, mandatory delousing when maximum limits of sea lice are demonstrated, and administrative fines when regulations are violated (Eithun 2000).

While the regulations have attempted to offset the spread of disease, a study conducted by the Norwegian Institute of Marine Research indicated that in the spring of 1999, salmon lice was responsible for killing 48.5-86% of wild salmon smolts when they were leaving the rivers. While it is not yet conclusive that salmon farming is responsible for this disease outbreak, the deaths were most often found in fjord systems where the highest density of fish farms are located (SeaWeb Aquaculture Clearinghouse 1999 (b)).

Historically Norway used extensive antibiotics to offset the risk of disease in farmed fish. However, from the period between 1980 and 1994, antibiotic use dropped from 60 percent of the farms using antibiotics to only 2.3 percent. Instead, vaccines have been used to control disease, which has saved salmon farmers money as well as decreased the incidence of fish disease (Hutchison 1999 (a)).

3.1.5 Waste discharge

Under the Norwegian *Pollution Control Act*, the Ministry of Environment issues permits governing waste discharge (B.C. EAO 1997 (c)). The permits are issued taking into account the ability of the receiving environment to deal with discharged organic matter, as well as issues associated with nature conservation, wildlife, and recreational uses in the area. In an effort to reduce pollution, a pollution control authority within the ministry established goals to reduce eutrophication, toxic effects, and effects of organic matter, oil, and chemicals.

The *Interim Fish Diseases Act* also contains regulations relating to waste discharge. For example, regulations prohibit the dumping of fish or fish parts and that the cleaning of fish and storage of dead fish must not cause annoying odors or serious harm to the environment. Dead fish must be removed from net pens every day in summer and every other day in the winter and must be ground and preserved in acid. In order to prevent the spread of infection, there are also approved methods and equipment for destroying dead fish and wastes as well as the treatment of effluent. For example, dead fish must be disposed of by incineration or burial at an approved site.

3.1.6 Interactions with marine mammals and other species

In Norway, there are limited regulations or guidelines that apply to interactions with marine mammals and other species. One regulation prohibits fish farming close to rivers, which are important to wild salmon populations. Another regulation provides that, if required, fish farms must be covered with netting to keep birds out (B.C. EAO 1997 (c)).

3.1.7 Salmon farm siting

The Ministry of Local Government and Labour regulate siting in Norway under the *Planning and Building Act*. In the 1980's, as the industry expanded, conflicts over appropriate siting for salmon farms became a key issue. To address this issue, a nationwide assessment of the suitability of the Norwegian coastal zone and rivers for aquaculture (LENKA) was conducted in 1987. The purpose of LENKA was to develop an overall assessment of the potential for aquaculture and to provide a basis for systematic development of the industry taking into account local environmental conditions and conflicts with other users. Selection criteria included prohibition of salmon farm sites in areas close to rivers important to wild salmon populations. In addition, expansion of fish farming is only permitted in salt-water areas with adequate water exchange and where chances of eutrophication, reduced oxygen concentration, or accumulation of sediments under culture systems are limited. There are also spacing requirements that maintain a distance of at least one kilometer between each fish farm (B.C. EAO 1997 (c)).

3.2 *Scotland*

3.2.1 Background

The first salmon farm began operation in Scotland in 1969 but the industry did not expand significantly until the 1990's. Between 1980 and 1991, Atlantic salmon production grew from 98 tonnes to 40,600 tonnes (Weber 1998). By 2000, production increased to 127,000 tonnes (Atkinson 2000). Originally most of the farm sites were located in protected areas such as fjords where there is little water exchange and therefore poor flushing of wastes. However, improved technology has allowed for more farms to be situated in open waters where there are better flushing capabilities.

3.2.2 Regulatory framework

The Scottish Office is responsible for coordinating the regulation of the salmon farming industry while the Scottish Office Development Department coordinates the planning regulations. The Crown Estate Office is responsible for regulating siting decisions, approval of leases, and charging rent for farm sites.

The Scottish Office Agriculture, Environment, and Fisheries Department is responsible for the protection of fish, fisheries, and the marine environment. When making farm siting decisions, this department advises the Crown Estate Office on issues related to disease control, existing fishing interests, and inshore marine environmental conditions.

Under the Scottish *Environment Act* (1995), an environmental protection agency was established to consolidate the regulatory powers of various organizations (B.C. EAO 1997 (c)). The main function of the agency is to protect the environment by controlling pollution to land, air, and water. More specifically related to salmon farming, the agency is responsible for promoting clean tidal waters, the conservation and enhancement of the natural beauty of coastal waters, and the conservation of aquatic flora and fauna.

Fish farm operators are not required to obtain a license to operate, however, they must obtain a lease. In order to do so, they must provide information to the crown estate commissioner on the position and size of the proposed site, types of equipment to be used, and species to be farmed, as well as target output, and any requirements they may have for onshore facilities. Once an

application for a lease is received, there is a 28-day period where comments from the public, other government agencies, and nongovernmental organizations on a proposed site are welcomed. Once these comments are received, the possible effects on navigation, sailing, fishing, amenity, ecology, and other fish farms are taken into consideration. In cases where conflicts are identified, a lease applicant may be required to modify a proposal. To deal with particularly contentious applications, an independent advisory committee may be consulted. Once a lease is granted, a farm operator is responsible for paying an annual rent based on the level of production on the site.

In some cases environmental assessments may be required in areas that are considered very sensitive, in enclosed inshore areas, and in open sea areas prior to obtaining a lease. In these areas, an applicant must submit an environmental impact statement outlining potential impacts and methods that will be used to mitigate these impacts, as well as a description of a proposed monitoring program. The requirement to conduct these environmental assessments, however, is often waived (B.C. EAO 1997 (c)).

Although there are a number of government departments responsible for regulating salmon aquaculture in Scotland, the regulatory system has not kept pace with the growth of the industry. The current regulatory system focuses predominantly on determining the siting of fish farms, controlling effluent discharge, and monitoring impacts of effluent discharge. Since 1991, the Scottish government has produced three drafts of legislation aimed at improving the regulation of the salmon farming industry, however, none of these drafts have been accepted and enacted. The Scottish Salmon Growers Association believes that its industry is the most tightly regulated in the world. This point of view is challenged by the Scottish Environment Protection Agency (SEPA) which has called on government to enact more efficient and effective controls on regulating the industry. This lack of regulation led to a court action in 1999 by 150,000 anglers accusing the government of failure to regulate the salmon farming industry (Staniford 1999).

In June 1999, a tripartite working group was established to identify solutions for promoting a sustainable salmon aquaculture industry, while at the same time maintaining stocks of healthy wild fish. The group is made up of representatives from the Scottish Executive Rural Affairs Department, the salmon farming industry, and wild fisheries interest groups. The group

produced a report in July 2000 outlining a number of recommendations with the principal conclusion being that there needs to be better cooperation at a local level. They recommended each region establish local management agreements. Three management agreements have been concluded and efforts are underway to encourage other areas to initiate similar agreements (Fisheries Group 2001).

In addition to government regulation of the industry, a product certification scheme was introduced in the United Kingdom to encourage salmon farmers to adopt better environmental practices. If the salmon are raised under strict standards that include rigorous and independent inspections at all stages of production, the salmon can be tagged with a "Tartan Quality Mark" (Scottish Quality Salmon 2001).

Controversy over the impacts of Scottish salmon farming on the environment escalated in recent years. This led, in June 2000, to demands for an independent inquiry into the environmental effects of salmon farming as well as an examination of the lack of adequate regulation and management of the industry. Unless the industry improves waste technologies and its environmental practices, some officials are of the view that the inquiry could lead to a moratorium on expansion of salmon farms (Carrell 2000). Simultaneously, SEPA announced it would tighten its regulations on the siting of salmon farms, chemical use, and waste discharge. In addition, the agency indicated that in situations where companies are not adhering to existing waste discharge regulations, it will revoke licenses and has threatened to relocate certain fish farms (Carrell 2000). However, the minister of Environment and Rural Development indicated in May 2001 that he is not certain that "an independent inquiry would be the best way to proceed at this time" (Friends of the Earth Scotland 2001).

3.2.3 Escaped farmed salmon

It is a statutory offence to permit the unauthorized release of nonindigenous species of salmon in Scottish waters. In addition, a civil liability case could be pursued where the release of genetically dissimilar stocks of salmon is shown to have adversely affected native stocks. When fish escapes do occur, details surrounding identity of the companies involved, or information that may be commercially sensitive, cannot be released without permission from the companies concerned. This information is protected under the Scotland *Diseases of Fish Act* (1937).

However, in 1997, concerns over numbers of escapes led to the establishment of a committee that was mandated to develop recommendations on how to deal with this issue. During the three years it took for the committee to release its nine recommendations, escapes quadrupled and farmed escapees outnumbered catches of wild salmon by more than four to one. In addition to these recommendations, the Salmon and Trout Association and Friends of the Earth Scotland made nine of their own recommendations including:

- mandatory recording of all escapes
- a public register of escapes
- fines imposed on farms guilty of allowing escapes
- compensation for recapturing costs
- compulsory tagging of farmed stock
- licenses for farms in unsuitable locations be revoked
- banning of salmon farms at sites near the mouths of salmon rivers
- re-siting of farms in high risk areas
- promotion of land based containment (Edgar 2000).

3.2.4 Fish health

All fish farmers must register with the Scottish Office of Agriculture, Environment and Fisheries Department, which is responsible for controlling disease outbreaks. In the case of an outbreak, fish farm operators must notify this department on the type of outbreak as well as methods used for treatment and disposal of infected fish. The department is also authorized to carry out annual surveys of fish farms to determine the presence of disease (B.C. EAO 1997 (c)).

Therapeutants, governed by the Scotland *Medicines Act* (1968), are authorized only where there have been no demonstrable effects on humans, animals, and the environment. Medicines must be administered under the guidance of a qualified veterinarian. In special cases, a veterinarian may permit the use of an unlicensed medicine if it is determined that there are no effective alternatives.

As sea lice have been a prevalent problem in Scottish fish farms, the use of therapeutants to control sea lice outbreaks has been given special attention. Their use is regulated based on site-

specific environmental conditions, a detailed risk assessment of the chemical, and on the potential cumulative effects on the receiving environment.

Despite these efforts to control disease and protect fish health, outbreaks of diseases such as infectious salmon anemia (ISA) and sea lice have adversely affected farmed salmon and potentially wild stocks. For example, in July 1999, an outbreak of ISA resulted in salmon farmers having to destroy four million infected fish. The Scottish Office offered fish farms nine million pounds sterling to offset their losses. This caused considerable controversy among other groups who felt that taxpayers should not be responsible for supporting the salmon farming industry (Seaweb Aquaculture Clearinghouse 1999 (b)). In particular, the Scottish Anglers' National Association felt that the industry needs tighter regulations and that until the industry is better managed it should not be subsidized. This lack of management is highlighted by the fact that it was the illegal importation of fish from Norway that likely resulted in the disease outbreak. The situation was exacerbated by the fact that the salmon farming industry is 47% owned by Norwegian companies (SeaWeb Aquaculture Clearinghouse 1999 (b)). In an effort to address the issue of ISA outbreaks, an aquaculture health joint working group was established and first met in February 2000. The group is mandated with attempting to identify ways to improve the general health, welfare, and management of salmon aquaculture and to produce annual reports with recommendations. It was agreed that most of the recommendations would be implemented by a code of practice. Since the group was established, a draft ISA code of practice was presented for approval. Other efforts to address ISA include a proposal to amend the Scotland *Diseases of Fish (Control) Regulations* (1994) to include the lifting of the prohibition on vaccination. In addition, state aid to assist farmers affected by ISA has been approved (SeaWeb Aquaculture Clearinghouse 1999 (b)).

It is also claimed that sea lice infestation in some areas of Scotland has been associated with salmon farming and has resulted in a significant decline of local wild fish stocks (Currie 1999). As sea lice are not considered chemical pollution or effluent, there appears to be controversy over which government body is responsible for dealing with this disease, resulting in a regulatory vacuum. Some believe SEPA should take responsibility for this issue and that it has the legislative powers necessary to do so. SEPA, however, takes the position that, ". . . the imposition of restrictive conditions on the discharge of sea lice or pathogenic bacteria is

considered to be unreasonable and *ultra vires*" (Currie 1999). However, in July 2000 a sea lice outbreak was illegally treated using two toxic chemicals not authorized for use to treat infected fish. As a result the company responsible was stripped of its "Tartan Quality Mark." For the first time, SEPA and the Ministry of Agriculture, Food and Fisheries launched a criminal inquiry, which, if successful, will lead to prosecutions (Carrell 2000). Furthermore, a regional director of SEPA expressed the opinion that sea lice from farmed salmon is harming wild stocks beyond a reasonable doubt (Myles 2000).

3.2.5 Waste discharge

In an effort to control waste discharge in Scotland, all fish farms must obtain a license to discharge pollutants into fresh and coastal waters. SEPA is responsible for issuing these licenses and takes into consideration sampling provisions, discharge quality, record keeping, and steps to minimize environmental effects of pollution. In established sensitive areas, more detailed monitoring may be required (B.C. EAO 1997 (c)).

The Western Isles Council inspects farm sites twice a year to assess the aesthetic quality of the shores located near fish farms and periodic audits are conducted to verify data provided by farms that conduct self-monitoring. It was determined that this method of monitoring was not sufficient and SEPA recommended a more extensive monitoring program be implemented (B.C. EAO 1997 (c)).

The issues of waste discharge and pollution have escalated recently. Evidence suggests that there have been 35 pollution incidents involving fish farm effluent since 1996, 26 of which occurred in the past two years (Friends of the Earth Scotland 2001).

3.2.6 Interactions with marine mammals and other species

To minimize interactions between salmon farms and other species, fish farms must be sited with a minimum half-mile distance from wildlife colonies and antipredator nets should be employed (EAO 1997 (c)). It is possible to obtain a license to kill seals in specific seasons and if certain conditions are met, such as the use of approved killing methods. As well, the Scotland *Wildlife and Countryside Act* (1981) specifies prohibitions regarding the killing of birds and other wildlife. There are exceptions to these prohibitions, however. For example, it may be possible

for an authorized person to kill or injure some species of birds if they are damaging fisheries. Other wild animals that are not specifically listed in the *Act* are subject to predator control.

3.2.7 Salmon farm siting

The Crown Estate Office established guidelines on siting of fish farms in Scotland to minimize conflict with other users, and for environmental protection. These guidelines relate to allowable distances for fish farms from other uses. Fish farms should be situated:

- 5 miles from another finfish farm, although closer siting may be possible between small-scale farms and in large loch systems or open water
- 2 miles from a shellfish farm
- 1 mile from public viewpoints, hotels, and tourist centers although concealment by headlands or woodlands may permit closer siting
- 1 mile from houses other than staff residences although the attitudes of residents are to be taken into account and may permit closer siting
- 0.5 miles from wildlife colonies, assuming effective antipredator control
- 0.25 miles from anchorages and approaches subject to the assessment of the Department of Transport
- 0.25 miles from fishing grounds, assuming that the fishing grounds concerned are specific productive areas in frequent use (B.C. EAO 1997 (c)).

While these siting distances are relatively specific, they are only guidelines, not regulations, and therefore are not mandatory. In November 1999, the Scottish Executive released additional siting guidelines, which included a detailed categorization of areas, such as those where new development or increased production will only be acceptable in exceptional circumstances (Staniford 1999).

3.3 Chile

3.3.1 Background

Chile is the second largest producer of farmed salmon in the world. There are numerous conditions that make salmon farming ideal in this country such as protected sites, stable water

temperatures, lack of pollution, a viral disease-free environment, as well as many hours of sunlight. These conditions have contributed to faster growth of salmon to market size. In addition, local access to sardine and anchovy stocks keeps feed prices for salmon lower than in other jurisdictions. Furthermore, lack of economic development provides a ready labor force that does not demand high wages.

In the 1980's, the number of salmon farms in Chile doubled. Production grew from one tonne of salmon in 1981 to 34,000 tonnes in 1991 (Weber 1998). It was not until 1987 that Atlantic salmon was introduced into Chilean waters. Prior to that time, only coho was raised which, unlike Atlantic salmon that can be harvested throughout the year, can only be harvested for three months of the year. By the year 2000, production had increased to 297,900 tonnes (Atkinson 2000). Nearly all farmed salmon in Chile is exported, primarily to Japan and the United States, representing an industry of over $US 1 billion in 2000. Salmon farming is now Chile's fourth most important export industry following copper, fish extraction, and fresh fruit. The goal is for the country to become the largest salmon producer with annual sales of $3US billion by the year 2010 (Martinez 2000).

3.3.2 Regulatory framework

The Chilean government has virtually no role in salmon production or exports. However, there are a number of laws that have been passed over the years to govern the aquaculture industry.

In 1991, a Chilean *General Law of Fisheries and Aquaculture* was enacted to regulate the fishing industry (B.C. EAO 1997 (c)). Some regulations contained under the *Act* deal with the granting of leases and licenses, establishing a national registry of aquaculture operations, establishing the number and size of cultivation structures, procedures for importing aquaculture species, certifying imported species are disease free, and approving importation of species for the first time. If the *Act* is violated, fines may be issued based on the number of species on the fish farm. The manager of the fish farm may also be personally penalized.

In 1994, a law was passed that requires new projects go through an environmental assessment if the project exceeds certain thresholds. These threshold levels have yet to be set. It is possible to avoid an environmental assessment if a proponent signs a declaration that indicates a project will

not have an environmental impact and accepts full responsibility if impacts do occur (B.C. EAO 1997 (c)).

In 1998, an environmental certification project for Chilean salmon farming was initiated and completed in December 2000. As part of the project, a code of environmental practices was established that provides criteria for sustainable development of the salmon farming industry. The code outlines procedures for the entire life cycle of the salmon farming process from broodstock to final harvest. The procedures or guidelines are voluntary, but if a salmon farming operation follows these procedures they may apply and qualify for an ecolabel (Fundación Chile 2000).

Salmon farmers must obtain a concession to operate a farm, which is similar to a lease or license. Once a request is authorized, a concession is granted for an indefinite period of time and can be transferred, leased, and sold.

3.3.3 Escaped farmed fish

Problems related to fish escapes are referred to in the Compendium of Chilean Aquaculture but there are no specific regulations that apply to preventing escapes (B.C. EAO 1997 (c)). Escapes are becoming a problem in Chile, however, as it has been determined that escaped farmed salmon have established runs in southern Chile where salmon are not indigenous. Concern has been expressed that these new runs will affect Chile's 250 native species in competition for food and habitat. In one case, Atlantic salmon that were caught from a nearby salmon farm were suffering from epidemic diseases and the fish farmer was accused of releasing the fish so he would not have to dispose of the dead fish (Hutchison 1999 (a)).

It is illegal for fishermen to catch and sell escaped salmon as it has been determined that all salmon belong to the farms. Sports fishermen are permitted to catch and eat escaped fish but they are not permitted to sell them. Nevertheless, they are sold on the black market and there is also an issue of salmon farms being robbed occasionally for the same reason. Some farms have employed guards with guns to watch the nets 24 hours a day as other methods of enforcement have not been effective (Hutchison 1999 (b)).

3.3.4 Fish health

Chile has enacted the *Regulations for Health Certificates for Importing Hydrobiological Species* that requires imported species be certified free of disease by an official authority in the country of origin (B.C. EAO 1997 (c)). Historically, Chile relied primarily on importing eggs for salmon farming. However, concerns over outbreaks of ISA in other countries led to the Chilean government placing increasingly strict requirements on imports of fertilized salmonid eggs. In July 2000, requirements became even more restrictive and in October of that year an import protocol was issued which required a 120-day quarantine period once imported eggs arrived in Chile. These restrictions were met with criticism from supplier countries and in December 2000 the restrictions were slightly modified to reduce the quarantine period. However, supplier countries are still concerned that these restrictions effectively block imports that in 1999 were valued at $8.65US million (Stockard 2000). In the meantime, the Chilean government is encouraging expansion of domestic production to offset the decline in imports.

Chile uses 75 times more antibiotics than Norway and a recent environmental study indicated that this extensive use of antibiotics is contaminating coastal waters and inland lakes (United Press International 2000). However, the industry invested $US 50 million in 2000 to find alternatives to antibiotics. Some alternatives being examined are switching to vaccines, developing natural alternatives, and using sensors to judge when fish are full so there will be less waste. Other methods to prevent disease include leaving farm sites empty for six months to clean out viruses or parasites (Hutchison 1999 (a)).

3.3.5 Waste discharge

The *General Law of Fisheries and Aquaculture* allows for the development of regulations for environmental protection related to waste discharge, however, these regulations are not yet completed (B.C. EAO 1997 (c)). There is a movement in Chile to breed fish that produce less waste and in some areas artificial habitats are being created surrounding fish farms using clams to filter wastes. The industry also processes some waste products into fishmeal and pet food, which is profitable for the industry as well as reducing the amount of waste (Cable News Network 1996). In addition, salmon farmers are fighting logging and development around their sites as logging practices might pollute the water and detrimentally affect their farms (Hutchison 1999 (a)). Despite these efforts, in one region many native species began to disappear soon after

salmon farms became established and it is felt that this was due to contamination from waste discharged from fish farms (Hutchison 1999 (b)).

3.3.6 Interactions with marine mammals and other species

Currently, there do not appear to be any regulations dealing with impacts of salmon aquaculture on marine mammals and other species. Some fish farmers shoot sea lions that approach their net pens and in one case a colony of 700 sea lions was destroyed leaving only about 25 sea lions in the area (Hutchison 1999 (a)).

3.3.7 Salmon farm siting

In order to deal with conflicts surrounding aquaculture siting in Chile, a process for determining areas suitable for aquaculture was established, which takes into account environmental issues and conflicting uses. Commissions were set up in each aquaculture region in Chile where various interests could be heard. The maritime and fishing authorities make final decisions. These decisions are issued in the form of a decree, although decisions have not yet been made in many aquaculture regions. In some areas concerns have been raised that salmon farmers block the way for local fishermen (Hutchison 1999 (b)). With respect to spacing requirements, bylaws have been established regulating the minimum distance between net pens. There has been some discussion in Chile over the use of lakes and rivers for salmon farming development, but there has yet to be any clear policy on this issue and this is considered a significant problem to the industry (B.C. EAO 1997 (c)).

3.4 Washington State

3.4.1 Background

Salmon farming began in the late 1960's in the Pacific Northwest of the United States. At that time the industry focused primarily on raising smolts. Commercial salmon farming did not begin in this region until the 1970's. By 1980, 329 tonnes of salmon were produced while by 1991, 7,100 tonnes of salmon were produced, principally in Washington State (Weber 1998). While there are other areas in the United States, such as Maine, California, Idaho, and Oregon that practice salmon farming, the focus of this paper will be on Washington as the industry is located in a geographically similar region, and is also directly affected by, salmon farming operations in B.C.

The salmon farming industry in Washington now produces over ten million pounds of salmon each year with an economic value of just over $US 40 million (Amos and Appleby 1999). Although the size of the industry in Washington is approximately ten times less than that of B.C., the United States exerts a large influence on world salmon prices through its capture fisheries for salmon.

3.4.2 Regulatory framework

There are three main government departments that have authority over the salmon farming industry in Washington. The Departments of Agriculture and Ecology (DOE) are responsible for regulating the industry and the escape of fish. The Washington Department of Fish and Wildlife (WDFW) has a mandate to manage fish and wildlife in the state but has limited authority over private aquaculture. Their authority is limited to disease prevention and control. It is only after fish have escaped that this department can take action. DOE is responsible for the promotion and marketing of cultured salmon as it was concluded that commercial aquaculture is similar to farming (Amos and Appleby 1999).

In the 1980's, it was determined that an environmental impact statement was required to assess the impacts of salmon farming in Washington. WDFW was mandated with conducting this review, which considered issues such as importation of new fish species, genetic interactions, disease transmission, and other environmental impacts. As a result of this study, new policies and regulations were implemented in 1987, which are discussed in more detail below.

Specific funding is not provided for the regulation and management of salmon aquaculture in Washington. It has also been suggested that authority over the industry should not be fractured among three agencies. As a result, in 1999 WDFW requested the Senate grant one agency authority over salmon aquaculture. Scientists within the department also felt that more comprehensive regulations are required to ensure salmon farming operations are more environmentally sound. WDFW has also been meeting with representatives from B.C. to discuss salmon farming issues, and they would like to establish an intergovernmental agreement recognizing that these issues are regional and should be dealt with accordingly (DeLong 1999).

In order to apply for a salmon farm, an application must be made under the Washington *State Environmental Policy Act* (1971). An environmental impact assessment is usually required as part of the application. Prior to the granting of permits, all projects in the coastal zone must be certified by DOE under the Washington *Coastal Zone Management Act* (1972), which ensures projects are consistent with the state coastal management program. Once a project is approved a number of permits are required to operate a salmon farm. A shoreline permit must be obtained under the Washington *Shoreline Management Act* (1971). This *Act* establishes a broad policy giving preference to uses that protect the quality of the water and the natural environment as well as preserve and enhance public access and recreational opportunities. If a salmon farm is located in an area that may impact migratory salmon, a hydraulic project approval must be obtained from WDFW. A net pen lease must also be obtained from the Department of Natural Resources. Other permits may be required if the location of a salmon farm has the potential to affect navigation. Some salmon farm operators have found it so difficult to get a salmon permit that they have given up trying. For example, one operator spent $5,000 US and five years to get such a permit, which then went through 13 appeals before being approved in 1992. This was the last permit granted in Washington (Hutchison, 1999 (c)).

3.4.3 Escaped farmed salmon

Under the *Revised Code of Washington* (1998) it is against the law to knowingly release fish into state waters without a permit. If fish are *accidentally* released, this does not constitute a violation of the law and no action can be taken. Before 1996, there were no significant escapes noted in Washington. However, in that year 107,000 Atlantic salmon were reported escaped. This was followed in 1997 by 369,000 escapes and in 1999, 115,000 escapes were reported (Amos and Appleby 1999). While WDFW has authority to manage escapes, it does not have the authority to control net pen operations or to mandate preventative measures. The issue of escapes is exacerbated by the recent listing of many stocks of Pacific salmon as threatened or endangered under the United States *Endangered Species Act* (1973). Under this *Act* chinook salmon have been listed as threatened in Puget Sound, although not as yet on the Washington coast. Coho is also a candidate for being listed as a threatened species. The United States Department of Commerce, National Marine Fisheries Service, is responsible for determining whether an activity, such as salmon farming, constitutes a "taking" of a listed species under the *Act*. "The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or

collect, or to attempt to engage in any such conduct." As escaped Atlantic salmon associate with Pacific salmon species, there is a potential that this association may be determined a "taking" of listed salmon species. If such a determination is made, salmon farmers in Washington may be required to obtain a "take" permit to continue operations. While the overall effects of this new legislation remain to be seen, salmon farming practices in B.C. could potentially impact listed species.

3.4.4 Fish health

WDFW is responsible for administering fish disease control and prevention regulations. While WDFW has authority over disease control, import, export, and transport, as indicated above, this department is only authorized to take action after an escape has occurred and there is a possibility of disease transmission to wild stocks.

Concern over disease transmission to wild stocks led to the implementation of new policies and regulations by WDFW in 1987, which were based on information obtained from state, federal, tribal, and industry representatives. However, it was felt these regulations were not adequate to prevent disease transmission to wild salmon stocks. Therefore, a more comprehensive group of aquaculture disease control rules were adopted containing provisions regarding importation criteria, reporting procedures, emergency quarantine provisions, inspection authorization, and record keeping requirements (Washington State Register 2000).

The use of disease control drugs and chemical use by salmon farmers must follow product label instructions, approved protocols, or be administered by, or under the supervision of, a licensed veterinarian. If the drugs used fall outside of these protocols, they must be approved in advance by DOE (B.C. EAO 1997 (c)).

To further reduce the risk of disease transfer there is a requirement for salmon farmers to obtain a permit from WDFW if they are importing or transporting finfish. Permit conditions are applied if it is concluded there is a reasonable risk of disease transmission between farmed and native species. Transport decisions are determined on a case-by-case basis and it is preferred that a five-year disease history of the fish and fry are provided. However, due to disease transmission concerns, most commercial broodstock are now locally raised (B.C. EAO 1997 (c)).

Farmed salmon stocks are screened annually for pathogens and there has not yet been a finding of a fish pathogen exotic to Washington or B.C. in Atlantic salmon. All fish pathogens that have been found in Atlantic salmon in this region appear to have historically existed in wild fish species (Amos and Appleby 1999).

3.4.5 Waste discharge

DOE is mandated with issuing waste discharge permits, which include waste discharge, sediment, and water quality standards. The waste discharge standards set thresholds for requiring a salmon farm operator to obtain a permit. These thresholds encompass annual production and feed consumption limits. In addition, if an individual fish farm is considered to be a significant potential contributor of pollution, a permit may be required. The waste discharge standards also provide that substances discharged into the marine environment must be treated. In some cases, more extensive treatment may be required if there is a reasonable probability that water quality standards will be exceeded
(B.C. EAO 1997 (c)).

The permits contain conditions including effluent limitations, monitoring provisions, reporting and record keeping requirements, operating conditions, and the preparation of a pollution prevention plan. A pollution prevention plan has to be presented within six months and must include operating procedures, spill prevention, spill response, solid waste, and storm water discharge. Salmon farm operators are required to be adequately trained on specific procedures related to the plan. There is also a provision for any interested party to appeal a permit within 30 days of it being issued. Initially all permits that were issued were appealed by environmental groups. The case was brought before a pollution control board that is responsible for adjudicating appeals to actions taken by DOE. In 1998 an agreement was negotiated between WDFW and the appellants, which removed WDFW as a party in the litigation. However, WDFW was designated responsibility for monitoring weirs, traps, and streams for Atlantic salmon. In addition, if Atlantic salmon are found, they must be killed and sampled for biological information. It was agreed that this information would be provided to the appellants on an annual basis (Amos and Appleby 1999). Further, in October 2000, a judgement denied the appellants appeal but specified a number of conditions for operating permits. These conditions required that DOE make certain amendments to the permits including research into

the viability of an all-female culture, implementation of escape prevention procedures and technology, and regular monitoring and reporting of existing sediment impacts zones 100 feet out from pens (BCSFA 2000 (d)).

A further issue that was determined during the hearings was that escaped Atlantic salmon were designated as a pollutant. Following this decision, the escape of 369,000 salmon in 1997 led DOE to require the offending salmon farm operator develop a fish release prevention plan and an accidental fish release response plan (Amos and Appleby 1999).

3.4.6 Interactions with marine mammals and other species

Siting guidelines recommend salmon farms be located more than 1,500 feet from bird and mammalian habitats of special significance. If a salmon farm is located in an area frequented by marine mammals, an exemption may be obtained permitting an operator to keep marine mammals from preying on farmed salmon under the United States *Marine Mammal Protection Act* (1972).

3.4.7 Salmon farm siting

As indicated above, an environmental impact statement is usually required prior to being granted a permit for a salmon farm. Guidelines for the preparation of a statement include siting requirements that take into account habitats that may have special significance. A salmon farm must also be certified by DOE to ensure projects are consistent with the state coastal management program (B.C. EAO 1997 (c)).

3.5 Conclusion

This chapter identified salmon aquaculture management practices in four jurisdictions. These management systems are analyzed in the final chapter and contrasted with conditions in British Columbia (Table 2).

Chapter 4 CONCLUSIONS AND RECOMMENDATIONS

This chapter provides an assessment of salmon farming management in British Columbia based on comparisons with salmon aquaculture practices in other jurisdictions, recommendations that have emerged from the salmon aquaculture review, information and opinions held by environmental organizations, and evaluation of the current regulatory environment in this province. A result of this assessment is a number of recommendations for both government and industry to encourage sustainable management of salmon aquaculture and to improve public perception of the salmon farming industry.

Table 2 provides a comparison of salmon farming management practices in all jurisdictions examined in this study. In some cases, information on certain practices was not available and was therefore indicated as "unknown". However, it is probable that in most circumstances a designation of "unknown" suggests the indicated practice does not exist in that jurisdiction.

Table 2
A Comparison of Salmon Farming in Five Jurisdictions

Criteria	Norway			Scotland			Chile			Washington			B.C.		
	Yes	No	?*	Yes	No	?	Yes	No	?	Yes	No	?	Yes	No	?
Regulatory Framework															
Central Authority		x			x			x			x			x	
License/lease required	x			x			x			x			x		
Revoking authority	x			x					x			x	x		
EA requirement		x		x			x			x				x	
Annual user fees		x		x				x			x			x	
Appeal mechanism			x			x			x	x				x	
Escaped Farmed Fish															
Legislation/Regulations	x			x				x		x			x		
Government notification	x			x				x		x			x		
Public notification			x		x			x				x		x	
Recapture requirements	x					x		x				x	x		
Closed containment		x				x			x			x	x		
Land based facilities		x				x			x			x		x	
Penalties	x			x				x		x			x		
Fish Health															
Legislation/Regulations	x			x			x			x			x		
Government Notification	x			x					x	x			x		
Public Notification		x				x			x			x		x	
Vaccine use	x				x		x					x	x		
Use of fallowing		x				x	x					x	x		
Government inspections			x	x				x		x			x		
Penalties	x			x					x	x			x		
Waste Discharge															
Legislation/Regulations	x			x			x			x			x		
Pollution prevention plans		x			x			x		x				x	
Use of artificial habitats			x			x	x					x		x	
Recyling initiatives			x			x	x					x		x	
Monitoring			x	x					x	x			x		
Marine Mammal Interaction															
Legislation/Regulations	x			x				x		x			x		
Use of netting	x			x					x			x	x		
Night lighting			x			x			x			x	x		
Acoustic deterrent devices			x			x			x			x	x		
Use of firearms			x	x			x			x			x		

Table 2-*Continued*

Criteria	Norway			Scotland			Chile			Washington			B.C.		
	Yes	No	?*	Yes	No	?	Yes	No	?	Yes	No	?	Yes	No	?
Siting															
Legislation/Regulations	x				x		x			x			x		
Spacing criteria	x			x			x			x			x		
Public input		x			x		x			x			x		
ICM process		x			x			x		x				x	
Voluntary Initiatives															
EMS		x			x				x			x	x		
Product certification		x		x			x					x		x	
Best management practices		x			x				x			x	x		

* unknown.

Note: Existing legislation and regulations are indicated by a "yes" or "no", however, the intent of such legislation and regulations varies widely among jurisdictions.

4.1 Regulatory Framework

The regulatory system governing salmon aquaculture has not kept pace with the growth of the salmon farming industry, either in B.C. or in the other jurisdictions examined for this study. The rapid growth of salmon farming has generally outpaced the preparedness of government to deal with the host of environmental, social, and economic issues generated by this industry. In most cases, the euphoria created by the perceived promise of wealth and employment led to a boom in an industry unfettered by restrictive regulations and bureaucracy. Only slowly have governments acknowledged the potentially serious environmental problems associated with salmon farming, and then, only after environmental groups and the public identified issues related to disease, environmental contamination, displacement of native fish stocks, and habitat damage. Being caught unaware, both the federal and provincial governments have had to rely on existing legislation to regulate salmon farming, even though such legislation might not be specifically related to aquaculture. This led, in Canada, to the situation where 17 federal departments and even more provincial departments, are directly and indirectly responsible for regulating fish farming.

One reason that legislation has been inadequate to manage salmon farming is that the scientific knowledge base used to develop specific regulations has not kept pace with the rapid growth of salmon aquaculture. Scientific research generally requires a relatively large amount of time and resources to produce sufficient data that can be used to identify and predict impacts. This is particularly true where environmental variability is large, such as that found among salmon farm sites. In the absence of reliable scientific data, it has been difficult to justify and impose effective limits and criteria. In B.C., this realization led to the moratorium on the issuance of new licenses to permit breathing room for a review of the likely impacts of the industry and to develop new strategies for effective management. The relative lack of scientific knowledge also prompted the auditor general of Canada to advise the precautionary approach to salmon aquaculture be incorporated in the decision making process, given that DFO does not have sufficient scientific information to ensure compliance monitoring and enforcement activities are effective in protecting wild salmon and their habitat.

4.1.1 Central authority

In all jurisdictions, there have been calls for consolidation of responsibility and for the formulation of effective legislation to deal with this relatively new industry. In B.C., it is important that the federal and provincial governments each identify one agency that takes the lead in the management and regulation of salmon farming. Federally, the aquaculture commissioner is presently reviewing all federal legislation that pertains to aquaculture. Presumably, the goal of this task is ultimately to produce new legislation that encompasses the federal responsibility toward salmon farming in Canada. Simultaneously, it is critical that new federal resources be allocated for scientific research into the environmental consequences of salmon aquaculture. While there are impacts that must be examined on a site-specific basis, considerable research could be conducted that would have national significance for salmon farming.

4.1.2 License and lease requirements

All jurisdictions examined require a license or lease to operate, however, the terms of the license or lease vary among jurisdictions. In B.C., salmon farmers have historically complained that the approval process for new licenses has been too lengthy, possibly taking up to three years. It is suggested that the approval process could be considerably improved through the establishment of an institutional arrangement that deals with issues related to salmon farming within the context of integrated coastal management. The technical advisory team recommended the creation of an advisory group to assemble and assimilate information from smaller local groups and then liaise with a committee charged with overseeing the integration of all the elements of an ICM plan for the entire B.C. coast. The end result of such a process would be to establish zones within the coastal area that are suitable for salmon aquaculture. This would considerably reduce the time and effort required to reach decisions on salmon farm license applications.

Given that the provincial government allocates land and issues licenses for salmon farms, and that SAR was undertaken under the direction of the former Ministry of Environment, Lands, and Parks and the Ministry of Agriculture, Fisheries, and Food, it would be appropriate for the provincial government to take the lead in developing coastal management to deal with the issue of siting new salmon farms. However, the mandate of the province to lead in this area would not give it the right to impose its view unilaterally. This process should involve all levels of

government, industry and interested stakeholders to increase the probability of successful implementation of this component of an ICM plan.

In order to integrate the activities of various levels of government into a management scheme involving the three nested councils or bodies indicated above, each level of government should participate in these councils. It would be essential that an effective and efficient communication network be established in order to ensure that each government remains fully informed on the activities and status of each council.

Salmon farmers in B.C. have also complained that while the normal 10-year lease is sufficiently long, it should not be tied to a specific location. Conversely, this restriction is important to confine the effects of a net pen site to one area, and to ensure that appropriate environmental reviews are conducted for all occupied sites. In Chile, concessions, which are similar to leases, are issued for indefinite periods and can be transferred, leased, or sold. While the advisability of such a system in B.C. is questionable, the Chilean experience should be evaluated for possible application, at least in part, in this province. Most important is the requirement that leaseholders respect responsibilities conferred by their lease and by government regulations, and are qualified to operate a salmon farm.

4.1.3 Revoking authority

Norway, Scotland and B.C. all have legislation that permits government authorities to revoke a license if an operator is not conferring with the terms of the lease. However, it appears that in all of these jurisdictions there are methods that can be used by farm operators to avoid this penalty. In B.C., while there have been situations of noncompliance, a license has never been revoked. This should not be the case, and licenses should be revoked when noncompliance is proven. This would serve as a strong deterrent to noncompliance with terms of a lease.

4.1.4 Environmental assessment requirements

TAT recommended that formal assessments under the B.C. *Environmental Assessment Act* should not necessarily be required for new salmon farm sites. It is, however, desirable that thorough assessments be conducted for each new site and that assessments also be conducted whenever salmon farm operators apply for lease renewals. While siting should adhere to zoning

plans produced as part of ICM, as in Washington State, site-specific conditions among salmon farm sites are sufficiently different to require detailed assessments. These include comprehensive sampling of existing biotic and abiotic characteristics to determine site suitability, establish baseline conditions, and develop locally applicable lease conditions and fish density limits. Availability of baseline data would be particularly useful to detect trends over time, and for comparison with results from detailed environmental assessments conducted as part of lease renewal applications.

4.1.5 Annual user fees

Currently, the maximum cost for a salmon farm license in B.C. is $200. This is an insignificant sum of money considering the size of the industry. Consideration should be given to the imposition of annual user fees, based on the level of production, as practiced in Scotland. These rents could be used to fund research and a more extensive monitoring program. Monitoring should be conducted to determine the environmental effects associated with net pen operations, particularly in regard to waste discharges, therapeutant residues in the surrounding sediments and biota, and habitat disruptions. If such funding were available, monthly monitoring results based on sediment and water collection and analyses, and underwater photography, could be submitted to a central provincial aquaculture agency. In addition, provincial officials should visit salmon farm sites more frequently than once a year to monitor compliance with terms of leases and other regulations.

4.1.6 Appeal mechanism

Washington appears to be the only jurisdiction that has a public appeal mechanism, which is only related, however, to the issuance of waste discharge permits. It is essential that the public be involved in all aspects of the decision making process, as exemplified by the ICM process. While appeals of licenses at any stage should be permitted, it is expected that ICM would generally obviate many public concerns, thereby reducing the incidence of appeals.

4.2 Escaped Farmed Fish

4.2.1 Legislation and regulations

None of the jurisdictions examined have developed adequate legislation or methods to prevent salmon escapes. While evidence of adverse impacts to wild stocks or habitat from escaped salmon is not yet established, opinions and positions on this issue have been clearly staked. The

lack of such evidence should not inhibit the formulation, implementation, and enforcement of strong legislation, regulations, and criteria to deal with this issue, as prescribed by the precautionary approach. There is ample evidence worldwide of environmental problems caused by governmental unwillingness to tackle controversial issues until all scientific evidence has been collected. Even in the face of such evidence, governments are often still reluctant to change the status quo, particularly when confronted with employment and socio-economic issues.

4.2.2 Government and public notification

All jurisdictions, except for Chile, have a requirement for government notification if escapes occur. However, notification does not ensure that penalties will be imposed or that an investigation of the causes for the escape will be conducted. In addition, no jurisdiction has a requirement to notify the public in such cases. It is suggested that if closed containment or land-based containment are not mandatory, both government and public notification of escapes should be required. This may encourage fish farm operators to apply stricter preventative measures to prevent negative publicity.

4.2.3 Recapture requirements

The recapture of escaped salmon is only required in Norway and B.C. although it is not possible to ensure complete recapture. Once again, closed containment or land-based containment systems would negate recapture requirements. However, in the interim, all efforts to recapture escaped fish should be required and programs such as the Atlantic Salmon Watch should be encouraged and expanded.

4.2.4 Closed containment and land-based facilities

Despite the existence of comparatively thorough farmed fish escape legislation in B.C., it is probable that escapes will continue to occur. Legislation will not contain fish in the face of violent storms, marine mammal predation, and most importantly, human error. For this reason, the pilot project initiative, funded by the salmon farming industry, to investigate the feasibility of closed containment or land-based systems, deserves considerable support and encouragement. This is because either closed containment or land-based salmon farming are the only ways to ensure that escapes will not occur. Closed containment or land-based salmon farming is discussed in this section because of the highly controversial issue of salmon escapes, which

would be prevented by a change to closed containment. However, closed containment or land-based salmon farming also have implications for the control or prevention of disease and parasite infestations transmitted by farmed fish to wild fish stocks, the prevention of environmental damage caused by waste discharge from open net pens, and the elimination of interactions with marine mammals and other predators.

At present, it appears that no jurisdiction included in this study utilizes closed containment or land-based salmon farming, except for the experimental pilot project currently being undertaken in B.C. The requirement in B.C. for closed containment or land-based salmon farm operations is inhibited by the industry position that high capital and operational costs are prohibitive. Possibly, these costs could be reduced through further experimentation and experience. At issue is the potential economic competitiveness of salmon farmed in conventional net pens from closed containment or land-based salmon farms produced at home as well as in other jurisdictions. If it is deemed to be in the public good to permit and encourage salmon farming in this province, then it would be folly to allow its demise through the imposition of requirements that are presently not competitive. Changes cannot be expected to occur overnight and a gradual move away from open net pen operations should be considered. To hasten these changes, the provincial and federal government should continue to pursue cooperative research with other countries into alternative technologies and methods of operation. This would help to reduce costs and perhaps ultimately, lead to international improvements in environmental management of fish farms.

4.2.5 Penalties

B.C. is touted by its politicians and salmon farmers as having the most comprehensive farmed fish escape legislation in the world. A review of the legislation and practices in the other four jurisdictions included in this study suggests that this position may be true. It appears that the province recognized public concerns regarding the potential impacts of salmon escapes and toughened existing regulations to place responsibility for escape prevention, reporting, mitigation, and costs primarily on the shoulders of the industry. Non-compliance penalties, however, may not be sufficient to deter unscrupulous or careless operators. For example, maximum fines are $2000/day if the regulations go unheeded. Instead, licenses should be

automatically revoked where it is determined that non-compliance is due to negligence, as is presently authorized by the legislation.

4.3 Fish Health

4.3.1 Legislation and regulations

Recent changes in salmon farming practices in B.C., particularly through the implementation of the new fish health code of practice, should help to reduce disease outbreaks and decrease the use of potentially harmful therapeutants. B.C. and Canadian regulations regarding the use of therapeutants, and restricting the importation of fish and gametes are already relatively comprehensive. However, consideration should be given to a closer examination of legislative initiatives employed in other jurisdictions to reduce environmental health risks associated with salmon farming.

While one of the general terms of a license in B.C. includes a specification of the production levels to be farmed, it does not appear to be strictly regulated. Therefore, the density of fish permitted in net pens should be determined based on scientific studies and should be better regulated, as is practiced in Norway. Excessive concentrations of fish can result in increased stress, disease transmission and the concomitant use of therapeutant controls. While it is seemingly self-evident that salmon farmers would place caps on net pen densities in order to lessen disease risks, there may often be financial and competitive pressures to exceed safe limits. Thus the appropriate regulatory agencies should regulate these limits for the protection of the environment and the salmon farming industry alike.

Therapeutants used in B.C. on farmed salmon have not necessarily been subjected to site-specific environmental assessments. This is particularly true of extra-label therapeutants prescribed by veterinarians, where drugs or chemicals are used that have not been specifically approved for use on net pen fish. Ecological risk assessments should be required for all chemicals used in B.C. salmon farms, either on a site-specific or region-specific basis, as is practiced in Scotland. Such risk assessments should include an analysis of cumulative effects, especially where synergistic impacts could occur from the use of more than one therapeutant at a time. It is particularly important that these analyses be conducted prior to the use of any chemical, to prevent the possibility of significant adverse effects to adjacent habitats and biota.

4.3.2 Government and public notification

In Norway, fish farmers must report therapeutant use, while therapeutant sales must be reported to the government by pharmacies and feed mills. Information from these varied sources is crosschecked to reveal and discourage unauthorized chemical use. A similar requirement should be implemented in B.C. It is further suggested that DFO include commonly used extra-label therapeutants in the random testing program and in reporting requirements. Currently, only notifiable or listed diseases must be reported to DFO in B.C. This requirement should be expanded to include all diseases. This practice would permit the early detection of unlisted, potentially serious disease organisms that may be new to the area.

No jurisdiction has a requirement to notify the public on issues associated with fish health. The government has a responsibility to test fish reaching the market and to ensure that human health is not compromised. Concerns have been raised in the media over the federal government's vigilance in this matter. While it is beyond the scope of this study to address this issue in detail, it is incumbent on government to ensure that the public is kept informed on human health issues related to farmed salmon. This would include the release of information regarding antibiotic, pesticide and toxic chemical residues found in farmed salmon and the potential risks from consuming these fish.

The Suzuki Foundation television broadcast of February 2001 indicated farmed salmon contain higher levels of PCBs, dioxins, and other persistent organic pollutants than wild salmon. While the salmon farming industry has challenged these results, further impartial studies should be conducted to determine whether there is cause for concern. This type of study is particularly important to ensure the public is provided with reliable information that would allay apprehension over any potential health risks that may be associated with farmed salmon.

4.3.3 Vaccine use

Both in Chile and Norway, fish are regularly vaccinated against common diseases. This practice significantly decreased the use of therapeutants. Similarly, approved vaccine use should be encouraged in B.C. Such an ongoing program would likely be cost-effective due to the potential for reductions in disease and stock loss, and because of the reduced environmental costs that may occur from extensive chemical use.

4.3.4 Use of fallowing

Salmon farm sites in Chile are periodically left to fallow for six months to permit a flushing of microbes, parasites and wastes. Some salmon farmers in B.C. occasionally leave their sites to fallow, but this is not a wide spread practice. The limited extent of this practice is probably due to the costs associated with leaving a site inactive for a period of time. However, the long-term benefits of healthier fish should offset the short-term costs. While the frequency and duration of such fallow periods should be site-specific due to widely differing oceanographic conditions, this practice would be beneficial and should be strongly encouraged in B.C.

4.3.5 Government inspections

Scotland, Washington, and B.C. all conduct fish health inspections although the extent and frequency of such inspections varies among these jurisdictions. In B.C., random tests by DFO are conducted to determine the presence of unapproved antimicrobial compounds, pesticide residues, and heavy metals. Diseased or parasite-infected fish in B.C. fish farms are generally treated by drugs or pesticides that have been approved for that use by both the federal and provincial governments. Medication label directions must be followed explicitly. However, veterinarians can prescribe therapeutants that have not necessarily been approved for use on diseased fish. While it is likely that most fish farmers follow these requirements, the unauthorized use of chemicals and drugs to treat fish would be difficult to detect, despite the random tests conducted by DFO. Extra-label therapeutants are not necessarily included in these tests. It is suggested that DFO conduct more frequent and more complete inspections to detect and discourage the use of unauthorized chemicals and drugs.

4.3.6 Penalties

It is inherent that if legislation requirements are not followed, penalties will ensue. However, the extent of these penalties may vary in their severity. No jurisdiction appears to have strict penalties that have managed to offset the incidence of disease outbreaks. Disease outbreaks are a reality, not only within net pens, but also among wild salmon populations. Therefore, a penalty associated with a disease outbreak is not warranted but the intentional noncompliance with therapeutant or pesticide regulations should result in revocation of a license.

4.4 Waste Discharge

4.4.1 Legislation and regulations

All the jurisdictions included in this study have legislation to restrict the discharge of wastes from salmon farm sites. The measures in force, or proposed, in B.C. to reduce and manage waste from salmon farms are progressive when compared with waste discharge control in the other jurisdictions examined. However, there are areas where significant improvements could be realized.

Only land-based or closed containment aquaculture can completely prevent existing contamination problems caused by the discharge of excess fish food and fish faeces into the environment. By their very nature, such technologies result in the complete collection of wastes, which must be disposed of in an environmentally safe manner. As long as existing net pen operations are allowed to continue, waste management is an exercise in control and reduction, but not complete elimination.

In B.C., extensive water and sediment sampling have been undertaken in the vicinity of all active salmon farms. These results, in addition to the results from studies that have been implemented at six salmon farms to investigate the relationship between waste deposits and impacts on benthic communities, will be used to develop performance-based standards for the industry. While it may be premature to formulate recommendations on this issue prior to the release of these standards, it is suggested that standards will only be effective in conjunction with permit application requirements that include environmental impact assessments. Permits should only be granted where ecological and cumulative effect assessments suggest that sites are situated in areas with suitable currents for flushing and where wastes would not pose significant risks to local biota or recreational uses. To encourage waste reduction, annual fees should be levied on fish farm operators commensurate with the type and amount of wastes discharged to the environment, as recommended by TAT.

4.4.2 Pollution prevention plans

Washington State is the only jurisdiction examined that requires a pollution prevention plan as part of permit requirements. This plan, which must be submitted within six months of obtaining a permit, includes operating procedures related to spill prevention, spill response, solid waste,

and storm water discharge. These procedures are not necessarily bound by specific criteria or legislation. Pollution prevention plans should be considered in B.C. as part of salmon farm permit requirements. However, these plans should be submitted and approved prior to obtaining a waste discharge permit. While it may be difficult to legislate specific criteria, the requirement to prepare pollution prevention plans would force salmon farm operators to give careful thought to the impacts of their operations on water quality and adjacent habitats.

4.4.3 Artificial habitats and recycling initiatives

Some Chilean fish farmers collect certain waste products for processing into fish meal and pet food. As well, biological waste controls are being investigated in Chile through the creation of artificial habitats surrounding fish farms to encourage waste filtering clam populations. In Chile, research is also being conducted into the breeding of fish that more effectively convert food to tissue, thereby reducing waste. These efforts should be followed and reviewed to determine their applicability in B.C.

4.4.4 Monitoring

Monitoring of water and sediment quality in the vicinity of salmon farm operations appears to be practiced more extensively in B.C. than in the other jurisdictions included in this study. However, this is a relatively recent development in B.C. that has been implemented jointly by the B.C. Ministry of Fisheries and the industry. Environmental effects monitoring, however, should be incorporated as part of salmon farm permits, since the onus for monitoring should be placed on salmon farm operators. Data collected as part of periodic water and sediment sampling would be submitted to the appropriate regulatory agencies. These data would permit early detection of potential problems, and be used to adjust operational practices, enhance scientific knowledge, and determine site suitability when lease renewals are requested.

4.5 Interactions with Marine Mammals and Other Species

4.5.1 Legislation and regulations

There appears to be little that can be learned from the other jurisdictions included in this study in regard to the control of predators that interact with salmon farms. In Scotland and Washington, fish farm siting is used in an attempt to distance salmon farms from potential predators and the use of predator nets is encouraged. No other legislation in any of the jurisdictions has been developed to expressly deal with the issue of predators.

The position of the B.C. government toward the killing of marine animals that damage salmon net pens and feed on the enclosed fish has been the same as that toward predators that impact on agricultural livestock. Since agriculture and aquaculture are both licensed and encouraged by government, it has been felt that it is necessary to deter and, if necessary, kill predators that threaten these industries. As such, restricted permits are granted to fish farmers for the purpose of killing marine mammals. This practice created considerable public opposition, particularly since it is often felt that the aquaculture industry is encroaching on the habitats of local marine mammals, not the other way around. The perception of the public of the salmon farming industry killing seals and sea lions has negatively affected the overall acceptance of salmon farming in B.C.

4.5.2 Use of netting, acoustic deterrent devices, and firearms

Closed containment or land-based salmon farming would eliminate interactions among predators and farmed salmon. However, until or unless such practices become the norm, predation will continue to be a factor. Such predation results in considerable losses to salmon farms, but also causes escapes of farmed fish, with resulting risks of disease transmission and displacement of wild stocks. For these reasons, and because it is recognized that the destruction of marine wildlife is not acceptable to the general public, the salmon farming industry has taken steps to identify nonlethal solutions to this problem, including the use of heavier gauge nets, semirigid net pens, predator screens, and other specialized predator-control equipment. Acoustic deterrent devices, once seen as a possible solution to the problem of predation, is no longer in favor for aesthetic reasons and because of concerns over the effects of noise on whales.

It is laudable that the salmon farming industry has taken steps to decrease the killing of marine mammals. Since destruction of predators is still permitted, however, additional measures should be instituted to further reduce these occurrences. TAT suggested that enforceable predator-control plans aimed at deterrence should be included in aquaculture licenses and further, that predators could be shot only if they are found inside net pens and actively killing fish. While the first of these two suggestions has merit, the second may not be realistic given that considerable damage to the net pens will have already occurred once marine mammals are found inside the nets. In addition to highly restrictive firearm permits and the mandatory reporting of all shots

fired and the circumstances surrounding these events, salmon operators should be obligated to pay a fixed sum for each marine mammal killed. Such a payment is suggested as both a deterrent to the excessive killing of wildlife and as an incentive to implement non-lethal deterrent methods.

4.6 Siting

4.6.1 Legislation and regulations

Fish farm siting in Norway, Scotland, Chile, Washington State, and B.C. are subject to assessments that take into account both environmental sensitivities and potential conflicts with other activities in the area. Generally, each jurisdiction has guidelines or regulations identifying minimum spacing requirements between fish farms and other uses, such as existing fish farms, recreational areas, habitations, mouths of rivers with salmon spawning runs, and marine parks.

In B.C. salmon farm applications were historically assessed on a site-specific basis with little consideration given to potential cumulative effects from other fish farms in an area. At present, there are no regulations imposing minimum distances between salmon farms. Such separations are determined based on predicted risks of disease transmission between sites.

As a result of inadequate environmental assessments, and unpredicted adverse impacts, three salmon farms have been relocated within B.C., and a number of others have been identified by the fish farm review committee as candidates for relocation. The relocation of fish farms should take precedence over the issuance of new licenses.

4.6.2 Public input and the ICM process

Decisions regarding relocations and any new licenses should only be made in the context of locally developed integrated coastal management (ICM) plans. In effect, such plans constitute coastal zoning initiatives based on consideration of environmental, social and economic criteria and cumulative effects. Despite differing opinions as to the effectiveness of the central coast LRMP and the Queen Charlotte Islands LRMP, these forums provided an opportunity to make progress in this regard.

The abundant rich information and data that would have to be considered as part of ICM could be effectively integrated through the development and reconciliation of overlapping coastal zone

plans and maps. The content and boundaries of such maps should be based on scientific studies, traditional knowledge, and extensive public input. This would help to promote cooperation among local community groups, environmental organizations, government, and industry. It should be required that comprehensive maps that demarcate habitats, resource uses, conflicts, and zoning identified through consensus be used in future salmon farm relocations and siting, provided that appropriate appeal mechanisms are included in the permitting process.

The opportunity map series prepared by B.C. Lands, which included public input to identify potential resource use conflicts, are a resource that could be considered in determining appropriate salmon farm siting. These maps designate three zones: conditional, limited, and no opportunity or high conflict zones. However, to date, there has been no requirement to adhere to the zoning indicated on these maps, as evidenced by the fact that salmon farms have been sited in no opportunity zones.

4.7 Voluntary Initiatives

4.7.1 Environmental management systems

Environmental and product certification by recognized international organizations may be desirable for salmon farming operations in B.C. to create uniformity and consistency within the industry with regard to environmental management, and to improve public perception regarding environmental stewardship by salmon farmers.

There appears to be two options for environmental certification for salmon farming operations that would be recognized internationally: certification by the Marine Stewardship Council (MSC) and registration to ISO 14001 standards. In addition, ISO 9000 provides opportunities for product certification. A brief outline of these programs follows.

MSC is an independent, charitable, not-for-profit, and non-governmental international organization working to achieve sustainable marine fisheries. It does so by promoting responsible, environmentally appropriate, socially beneficial, and economically viable fisheries practices, while maintaining the biological diversity, productivity and ecological processes of the marine environment (Marine Stewardship Council 2001).

MSC has developed three principles for the conduct and management of commercial, wild fisheries to ensure their sustainability. A number of criteria have been developed under each principle to facilitate their implementation. On a voluntary basis, independent, MSC-accredited certifiers can endorse fisheries that conform to these principles and criteria.

The International Organization for Standardization (ISO) is a non governmental, worldwide federation of national standards bodies from 130 countries. The mission of ISO is to promote the development of standardization and related activities in the world. It attempts to facilitate the international exchange of goods and services, and to developing cooperation in the spheres of intellectual, scientific, technological, and economic activity. ISO's work results in international agreements that are published as international standards (International Organization for Standardization 2001). The Canadian Standards Association (CSA) is the official Canadian representative on ISO and has the responsibility for the implementation of ISO standards throughout the country.

ISO 14001 is an environmental management system (EMS) that was developed by a technical committee made up of representatives from more than 100 countries. The main objective of ISO 14001 is to help organizations develop systems to manage environmental aspects of their operations and to work toward continuous improvement. ISO 14001 lays out environmental management systems; it does not establish specific environmental criteria or specifications. Therefore, conformance to ISO 14001 does not guarantee conformance to regulations. However, it does create a management environment that increases the likelihood that environmental targets in any country will be achieved.

ISO 9000 is a quality management system model. The standards written as part of ISO 9000 apply to a wide range of businesses, both manufacturing and those providing services. ISO 9000 creates a management system that helps companies achieve established product standards. However, it does not guarantee that product quality will conform to those established standards.

ISO 9000 and ISO 14001 are two separate standards. Therefore, organizations must be registered to each standard separately. There is already a precedent in Canada for the registration of a salmon farming operation to the ISO 9000 standard and one in B.C. that has received ISO

14000 accreditation. The reasons for registration to the ISO 9002 standard by the salmon farm operation on the east coast of Canada were to help the company control their management processes and to assist in marketing their products.

It is recommended that BCSFA encourage its members to apply for ISO 9000 and 14001 accreditation. This would serve to improve management efficiencies, create industry-wide consistency, enhance the image of the industry, and provide marketing opportunities.

4.7.2 Product certification

A further option that could be considered for BCSFA members is product certification. One example is the incorporation of an ecolabel, as used in Chile, or the Tartan Mark that is used in Scotland. There are a number of ecolabels in use throughout the world for a variety of different products. For example, in Norway, the Nordic Swan is the world's first multi-national ecolabeling scheme. This label is a neutral, independent symbol that guarantees a product meets high environmental and quality standards based on objective assessments. A comparable label is used for tuna that is considered to be "dolphin friendly" so that consumers know they are buying an environmentally friendly product. A similar system should be developed in B.C. Salmon farmers that adhere to strict environmental and product standards that include rigorous, independent inspections at all stages of production could market their product with an ecolabel. This type of labeling could provide salmon farmers with a positive marketing opportunity that would help enhance the image of the industry as a whole. It may also give B.C. salmon farmers a competitive advantage in an international market that is becoming increasingly environmentally aware.

4.7.3 Environmental donations

Salmon farmers should also examine the feasibility of donating a portion of their profits for environmental research or conservation. As an example, Banrock Station Wines of Australia has become well known and applauded internationally for its considerable donations to environmental projects from the sale of its products. The adoption of a similar practice by salmon farming companies would not only provide tangible environmental and scientific benefits, but its advertisement would also help improve the image of an industry that has been chastised for causing environmental damage.

4.8 Conclusion

The current environmental record of the salmon farming industry in B.C. is comparatively better than the other jurisdictions examined in this study. Generally, regulation and management of the industry are more closely controlled in B.C., and the industry has made progress towards reducing environmental impacts. However, the ongoing controversy in B.C. over certain salmon farming practices indicates that further change and improvement are necessary.

The regulatory framework for managing the salmon farming industry in B.C. has been lacking, and current legislation and regulations are inadequate. The attempt by the federal government in 2001 to review and revise aquaculture legislation is a step in the right direction but it remains to be seen whether the public and the industry will view the results favorably. Effective change will likely only result from decisions based on input from all stakeholders. This consensus-building approach could be implemented through implementation of ICM in B.C. This would have the advantage of involving resource users, the public, and government in determining the most effective sustainable uses of the coastal zone. A forum similar to the Land Resource Management Process would be a logical type of body to coordinate coastal actions in the province.

An ICM process, to be effective, must be built not only on multi stakeholder involvement, but also on a foundation of science and traditional knowledge. There is a considerable need in B.C., and elsewhere, for additional scientific information to help manage risk through accurate prediction of impacts. Since the growth of the salmon farming industry has outstripped the pace of scientific research, a priority of both government and industry should be studies into the individual and cumulative effects of salmon aquaculture and the mitigation of adverse impacts.

A move towards closed containment and land-based technologies might offset some environmental problems inherent in net pen salmon farming. In particular, this would prevent escapes of farmed salmon, thereby drastically reducing risks associated with the transmission of disease and displacement of wild stocks. It would also eliminate direct discharge of waste products into the environment. However, closed containment and land-based fish farming are not panaceas. Wastes must still be disposed of on land or at sea, although a greater degree of

control is provided by these technologies. In addition, disease outbreaks may still occur within such containments.

Despite efforts to improve management practices, public perception is swayed by the media's interpretation of the conduct of salmon farming. Therefore, it is critical that the public is provided with timely, accurate, unbiased information. While this may seem idealistic, it could be possible to move toward improved communication by fostering cooperation among environmental groups, industry, and government through multi-stakeholder involvement in future management decisions.

There is an opportunity for the B.C. salmon farming industry to take a more positive view of stricter regulations and associated costs of implementing the voluntary initiatives discussed above. The aggressive advertisement of its position as a world leader in environmental stewardship may create a unique niche for B.C. farmed salmon. This would enhance the competitive advantage for the B.C. salmon farming industry in a world that is becoming increasingly selective of products produced sustainably.

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